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ART. XVII.—*Photometric Experiments.* PART FIRST.—*On a simple form of Photometer for determining the amount of Light reflected by Metallic Surfaces at different incidences;* by OGDEN N. ROOD, Prof. of Physics in Columbia College.

THE fundamental idea of many forms of photometer is based on the comparison of two illuminated surfaces placed in immediate juxta-position, and the judgment of the experimenter is called on to decide when the brightness of these appears equal. If the difference of the two rival surfaces be considerable, the inequality will be perceived even by an unpracticed eye, but as the disparity is diminished the observer becomes less confident, and, passing into a doubtful and dissatisfied frame of mind, is at one moment inclined to consider the balance as gained, and at the next equally certain that it has been lost. It hence follows that no photometer of this form is adapted for investigations at all aiming at a refined character.

Bunsen, to whom Physics as well as Chemistry is under so many obligations, employs in the instrument which bears his name another principle: here, it is not the equality in the brightness of two adjacent surfaces, but the actual disappearance of a "spot" on an illuminated ground, the powers of the observer being now taxed to a much less extent, as it is merely a question of the visibility or invisibility of the "spot." The great superiority of this latter principle is evident from the mere statement, and it only remains to investigate how the proposed advantage can best be realized in actual practice. It is, I believe, generally admitted by those who have used Bunsen's photometer,

that with it, the end proposed is only approximately attained, the spot never becoming absolutely invisible, but merely assuming what may be termed an appearance of maximum faintness. Dove* has proposed a form of photometer, the general idea of which is not unlike that of Bunsen; it consists of a compound microscope provided with a microscopic photograph on glass, which serves as the "screen," the intention being to illuminate it from both sides, in such a way that the photograph should assume the same degree of brightness with its own border or ground, and hence become invisible after compensation. In a former number of this journal† I described a form of photometer partly based on this suggestion of Dove's, and at the same time detailed a few rough experiments that were made by its aid. Since then I have followed up the subject, and have examined somewhat, with the help of a more refined apparatus, the practical application of the physical and physiological principles involved in its more perfect construction and use.

The microscope and microscopic photograph I dispense with, gaining thus not only in economy but also in delicacy, while the plan of employing a silver-collodion film on glass was retained and proved of great value, and, as will be shown in the second part of this paper, the idea of a total disappearance of the "spot" was at length realized to the fullest extent, when the precaution of using an absolutely unvarying illumination was observed. I proceed now to describe the instrument, and will afterward add some determinations that were made by its help.

Description of the instrument. "*The Screen.*"—If we take a plate of glass covered by an opaque preparation, with a surface of some reflecting power, but without polish, and laying bare a small portion of the glass, say $\frac{2}{10}$ of an inch square and having backed it up by a plate of ground glass, illuminate it front and rear by two lights, it is evident that a mass of light will be reflected to the eye of the observer from the opaque pigment, while light coming from the second source will traverse the naked portion of the plate and reach the same destination. This second portion, or that coming from the "spot," will have commonly a greater or lesser degree of intensity than that *reflected* from the adjacent regions of the plate, so that we shall have either a bright spot on a dark ground, or a dark spot on a light ground, and an attempt to equalize the two illuminations, so as to effect the disappearance of the "spot," will be successful only under the following conditions:

First. All portions of the "spot" must be equally illuminated, and it must have no texture, that is, must not perceptibly consist of minute grains mingled with others having a less or greater degree of brilliancy.

* Pogg. Annalen, Band cxiv, p. 145. † Vol. xxxvi, July, 1863.

Second. All those portions of the ground surrounding and in contact with the "spot," must be equally illuminated, and the texture of the ground must likewise be uniform.

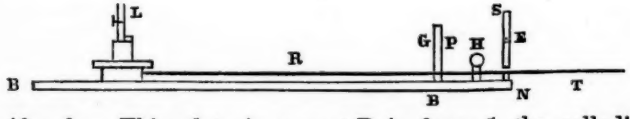
Third. The transition from the ground to the "spot" must be perfectly sharp and sudden, so that not the faintest border can be seen surrounding it.

Fourth. If it be required to render the invisibility of the "spot" more than momentary, it is equally essential that the ratio subsisting between the two sources of illumination should be truly constant.

If either of the first three precautions be neglected, the disappearance of the spot becomes entirely impossible, while it is only by a peculiar arrangement of apparatus that the fourth can actually be realized. (See second part of this article.)

Screen.—A plate of colorless glass of good quality is coated with photographic collodion and immersed for a few minutes in a solution of nitrate of silver, ("bath,") as though it was the intention to take a picture, ("negative"); it is then exposed for a minute or less to ordinary daylight, and a solution of photo-sulphate of iron poured over it. This produces a dense opaque deposit of silver in the substance of the film, when the plate is to be washed well in plain water and dried. Its surface will be of a grey tint, and will vary somewhat in its power of diffuse reflection according to the sample of collodion used. A small amount of light is also regularly reflected by the upper surface of the collodion film, and in using the plate it is always so placed that this latter portion shall produce no effect on the result. The collodion film is now removed neatly, by the aid of a needle, from a portion of the plate, so that a square with sides $\frac{2}{10}$ of an inch is laid bare, care being taken to leave the edges clean and well defined, in which there is no particular difficulty, provided the collodion was originally of the proper quality to cause it to adhere well. If the "spot" is made much smaller than the above mentioned dimensions it becomes an annoying object for observation, while if it be larger, it is difficult to illuminate it

1.



uniformly. This plate is seen at P, in figure 1, the collodion side being turned toward the eye of the observer, and the other side, except just opposite the spot, covered by a coating of lamp-black mixed with weak shellac varnish, so as to leave a black, non-reflecting surface. At the distance of an inch from the collodion plate, there is fastened, parallel to it, a plate of colorless

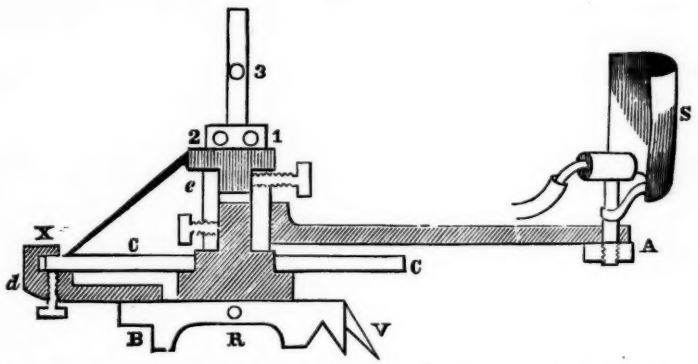
glass, G, finely ground on each side; this is destined to receive the light from L. If only one surface of the glass be ground, the texture becomes plainly visible, particularly when, as in the experiments detailed in the second part of this paper, the spot is magnified. Only so much of the ground glass plate is allowed to remain bare as is necessary, the remaining portions on both sides are covered by black non-reflecting paper. Plates P and G are then as it were roofed over, and enclosed on all sides by a small well fitting blackened case, destined to prevent the light from penetrating between them, and finally, to guard against possible errors by reflection from the walls of the room, plate G is provided with a projecting blackened tube which cuts off stray reflected light. P and G, constituting thus the screen, are fastened at the end of a pair of long parallel iron bars, B, B, made like the ways of a lathe, and provided with a scale graduated in millimeters. The length of this iron frame is six feet.

Source of illumination.—At E is the eye of the observer, the face being protected from light by the blackened screen, S. E, the center of the "spot," and the center of the mirror experimented on, all lie in the same line, which is of course at the same time the axis of the instrument. At H are two small gas flames issuing from circular apertures, and destined to illuminate the collodion plate on the side next to the observer; both are fed from the same source. The gas-burner at H consists of two thin brass tubes, half an inch in diameter and one inch long, connected together by a glass tube; the circular apertures for the flames are placed at equal distances on either side of the spot, and as far from it as is found most advantageous in any particular set of experiments; their distance from each other is seven inches. The direct light from the two flames is prevented from reaching the eye through the observing aperture, by small blackened screens, the same means being employed to arrest it in its course toward L. If instead of two, only a *single* gas flame is employed at H, the ground around the spot will be unequally illuminated, and exact observations become impossible. Of course the direct light from these two burners which penetrates through the "spot," must not be allowed to reach that portion of the ground glass opposite it; the distance of the flames apart must be so chosen that this becomes impossible.

The light from the movable burner on the other side of the screen at L will be used direct and reflected. The small *single* movable burner which supplies it, is similar to those already described, and to it is attached a flexible india-rubber tube, which is supplied from the same source that feeds H; it is connected by a *wooden* column, (for the sake of insulating the heat,) to the arm A, fig. 2.

I pass now to the joint support of the arm, A, and of the mirror to be experimented on. It consists of a block of brass,

2.



B, four inches square (see figure 2, which is one-third of the real size); its under surface is cut in such a way as to fit the two parallel iron bars and to slide on them easily but steadily, and this foundation block is farther provided with a vernier, V, to read off the distances on the millimeter scale. C is a graduated circle six inches in diameter, and is provided with a clamp at *d*. The hollow massive cylinder, *e*, supports the arm A, and also carries the axis of the support of the mirror. The screws, 1, 2, 3, serve to bring the mirror into its correct position; it is pressed against them by a band of india-rubber attached to the edges of the mirror. It will be seen that owing to this arrangement, all the different parts have motions quite independent, and yet by the clamping screws can at any moment be connected. Finally, attached to this stand is a long light rod of wood, R, reaching to the observer, and enabling him, by varying the distance between this movable piece and the fixed screen, to effect compensation.

Flexible Gas tubes.—It occurred to me that by splitting a stream of gas and sending one portion to L, fig. 1, the other to H, it would be possible to secure a uniform ratio between the two illuminations, as it would seem that any cause which increased the pressure in one of the branches of the tube ought to be equally operative in the other, so that after a compensation had been effected it should be permanent. In practice this was not found to be the case; the compensation point gradually shifted its position in the course of the evening away from H, sometimes to the extent of 50 or 60 millemeters. This difficulty was remedied by a suggestion from Mr. Lewis Rutherfurd, who suspected that the trouble came from the unequal length of the

two branches of the supply tubing, in point of fact, on giving them equal lengths and diameters, and making the compensations slowly, so that the branch attached to L was not much shaken or set in oscillation, this source of error became so greatly reduced as in no way to interfere with the observations.

Mode of measuring the amount of light reflected from a mirror.—To adjust the apparatus, it is first necessary that that diameter of the circle joining the 0° and 180° points, should be made parallel to the axis of the instrument, which is effected by the use of the vernier at X, fig. 2, the circle is then clamped. Next, the vernier attached to the mirror is placed at 90°, and the mirror itself is made to assume a position at right angles to the axis of the instrument, by the aid of its three screws, and a small gas flame placed on a support which rests on the parallel bars at a distance of two or three feet from the mirror, it being so contrived that the center of this small flame shall just lie in the axis of the instrument. The mirror is adjusted till it reflects the light of this small flame back to the eye through the flame itself, securing thus the collimation with the desired accuracy. The arm A is then set at any desired angle with the mirror, and the two clamped together, when it is easy to arrange matters so that the reflected light shall be sent from the mirror along the axis of the instrument to the fixed screen at G. The small shade at S, fig. 2, prevents the *direct* light from reaching the same destination. After a compensation has been effected with reflected light, the arm A is made parallel with the axis of the photometer by the aid of its vernier, and another compensation is made with the *direct* light, the small shade being now placed behind the flame so as to be out of the way and to prevent light from reaching the mirror.

Mode of registering the observations.—These were always registered with a sharp point on a slender fillet of paper, attached to the long wooden rod R T, fig. 9, used for moving the mirror. This point was one end of a small lever placed at N, fig. 1. In consequence of this, at the end of a set of experiments two groups of dots were found on the paper, admitting of the most exact measurement on the following day. Before removing the paper from the rod two dots were always made on it in the neighborhood of these groups, the corresponding positions of the vernier V, fig. 2, being at the same time noted. A glass slide, ruled with millimeter lines, was then to be placed over the detached fillet of paper, and the observations recorded in the note-book. In the determinations given below, the observations on the direct and reflected light were made alternate, so as to avoid errors due to the shifting of the compensation point.

Observations on the amount of light reflected by a glass plate silvered by Liebig's process, the *silver* side being used. The light was reflected at an angle of 45°.

1.

Distance when mirror was used.	Distance with free flame.
946	1297
949	1301
950	1302
951	1302
952	1304
955	1305
956	1306
957	1308
958	1309
961	1309
961	1310
962	1312
965	1312
966	1315
967	1318
967	
	15)19610
16)15323	
	1307·3
957·68	105·
Correction 191·	
	1202·3
1148·68	

Result 91·26 per cent reflected.

2.

Distance when mirror was used.	Distance with free flame.
936	1286
940	1287
941	1288
942	1288
943	1290
944	1292
946	1292
946	1293
947	1295
948	1296
949	1297
950	1298
952	1298
953	1301
954	1303
955	1303
956	1304
958	1305
959	1307
960	1307
961	1307
962	1308
965	1312
	1312
23)21867	1312
	1315
950·7	
Correction 191·	26)33796
1141·7	1299·8
	Correction 105·
	1194·8

Result 91·3 per cent reflected.

These figures are taken of course directly from the note-book, and in making an examination of them it is to be remembered that the corrections, 191 and 105, (for false positions of the vernier), are to be applied to each of the distances in the respective columns, before a correct judgment of the closeness of individual observations can be made.

When the same mirror was used at 5°, i. e., the light being reflected from it nearly perpendicularly, the results given below were obtained.

1.

Distance when mirror was used.	Distance with free flame.
955	1297
958	1304
958	1304
958	1305
960	1305
962	1307
962	1308
963	1310
963	1310
965	1313
965	1313
969	1313
970	1314
971	1314
972	1315
973	1318
977	1318
977	1328
980	
983	18)23596
983	
	1310·8
21)20324	105
967·8	1205·8
191	
1158·8	

Result, 92·35 per cent reflected.

2.

Distance when mirror was used.	Distance with free flame.
954	1298
955	1301
956	1302
957	1303
957	1303
958	1304
958	1305
961	1306
961	1307
962	1308
962	1308
963	1309
963	1310
964	1312
965	1312
967	1313
968	1315
969	1316
972	
	18)23532
19)18272	
	1307·4
961·6	105
191·	
	1202·4
1152·6	

Result, 91·88 per cent reflected.

In the second part of this paper I shall detail the results of several sets of experiments made with a truly constant illumination, in other respects the mode of experimenting being quite similar to that used in obtaining the above results, when it will be seen that about two-thirds of the scattering in the figures was due to the shifting of the compensation point during the experiments, and not to any defect in the screen.

In the same way experiments were made on another mirror silvered by Liebig's process, the glass side being used, with the result that out of a hundred rays 78·01 were reflected, the angle being 45°; while an amalgam mirror tested at the same angle reflected only 44·58 per cent.

Art. XVIII. — *Contributions to the Chemistry of Copper;* by T. Sterry Hunt, LL.D., F.R.S. Part 1.

[Read before the American Association for the Advancement of Science at Salem, August 25, 1869.]

§ 1. The resemblances between silver and copper in its cuprous form have already attracted the attention of chemists. The ordinary chlorid of silver (argentic chlorid) and the dichlorid of copper (cuprous chlorid) have many properties in common. Both of these chlorids are white, readily fusible, and blackened by exposure to light; both of them are insoluble in water but dissolve in ammonia and in aqueous solutions of other chlorids, in which however the cuprous is far more soluble than the argentic chlorid. A saturated solution of chlorid of sodium holds at 90° Centigrade, 16·9 per cent of cuprous chlorid, at 40° C., 11·7, and at 11°, 8·9 per cent. A solution containing fifteen per cent of chlorid of sodium retains at 90° C., 10·3 per cent of cuprous chlorid, at 40°, 6·0 per cent, and at 14°, 3·6 per cent; while a solution with only five per cent of chlorid of sodium holds of the cuprous chlorid at 90°, 2·6, and at 40° only 1·1 per cent. These determinations are from single observations and therefore require verification. From the sparing solubility of the cuprous chlorid in dilute solutions of chlorid of sodium it follows that the denser saturated solutions are copiously precipitated by dilution with water, which causes the separation of white cuprous chlorid in a crystalline condition.

§ 2. The aqueous solutions of the chlorids of calcium, magnesium, zinc, manganese, cobalt, ferrosum and cupricum, also freely dissolve cuprous chlorid, and it is probable that this property is shared by other soluble chlorids. The strong affinity of cuprosum for chlorine enables cuprous oxyd to decompose all the chlorids just named, with the exception of those of sodium and calcium, with separation of the corresponding oxyds and formation of cuprous chlorid. In the case of zinc and manganese, insoluble oxychlorids of these metals are formed at the same time. These reactions require further study, and the same may be said of the cupric and cobaltic chlorids with cuprous oxyd. I have, however, partially investigated the behavior of cuprous oxyd with magnesic and ferrous chlorids, and obtained the results about to be described.

§ 3. The cuprous oxyd for these experiments was prepared by gently heating a solution of sulphate of copper mixed with cane sugar and an excess of caustic soda, until the whole of the copper was thrown down as a bright dense cinnabar-red powder

which was carefully washed and dried. A concentrated solution of chlorid of magnesium dissolves this oxyd in the cold, and more readily when heated, with separation of hydrated oxyd of magnesium and cuprous chlorid, which latter is held in solution by the excess of magnesic chlorid. By filtering the liquid while hot, and washing with a strong solution of chlorid of sodium, the hydrate of magnesia may be separated, and the dissolved copper subsequently precipitated by metallic iron from the colorless filtrate, ferrous chlorid being formed. Experiment shows that the reaction between the red oxyd of copper and chlorid of magnesium may be represented as follows: $Cu_2O+MgCl=Cu_2Cl+MgO$.

§ 4. A solution of magnesian chlorid nearly saturated when hot with cuprous oxyd, and allowed to cool in contact with the precipitated magnesian hydrate, deposits a portion of orange colored oxyd, or perhaps an oxychlorid, which disappears as often as the solution is heated. The solid cuprous chlorid is moreover decomposed when digested with water and magnesia, hydrated cuprous oxyd and magnesic chlorid being formed. The double chlorid of cuprosum and magnesium is however stable, even in the cold, in presence of magnesian hydrate, provided a considerable excess of magnesian chlorid be present. From a filtered solution of cuprous oxyd in chlorid of magnesium water precipitates a large portion of the cuprous chlorid, in this case colored orange-yellow from adhering oxyd, due to the reaction of a little magnesia, which remains dissolved or suspended in the concentrated solution even after filtration. A solution of magnesian chlorid of specific gravity 1·23, retains in solution at 12° Centigrade, about 7·10 per cent of cuprous chlorid. A solution of magnesian sulphate with chlorid of sodium may be employed to dissolve cuprous oxyd. This, like all similar solutions of cuprous chlorid, rapidly absorbs oxygen from the air and deposits a pale green cupric oxychlorid.

§ 5. With ferrous chlorid and cuprous oxyd it might be expected, from analogy with the magnesian salt, that we should obtain cuprous chlorid and ferrous oxyd, but the reaction is complicated by the tendency of the latter to pass to the state of ferric oxyd. When ferrous chlorid in solution with chlorid of sodium is heated with a sufficient quantity of cuprous oxyd, the whole of the iron is precipitated as ferric oxyd, mingled with metallic copper, while cuprous chlorid remains in solution. Experiments made with an excess of ferrous chlorid show that one third of the copper is reduced, while two thirds are dissolved as dichlorid. This reduction may be effected directly by ferrous oxyd; if to a solution of cuprous chlorid in chlorid of sodium, we add hydrated ferrous oxyd recently precipitated by an alkaline base and still suspended in the liquid, it is at once

converted into ferric oxyd, with precipitation of metallic copper. The first stage in the action of ferrous chlorid on cuprous oxyd may be represented as similar to that of magnesic chlorid: $Cu_2O + FeCl = Cu_2Cl + FeO$. In the second stage $Cu_2Cl + 3FeO = Cu_2 + FeCl + Fe_2O_3$. It follows from this that one-third of the cuprous chlorid formed in the first stage is reduced to the metallic state, and the final result may be represented as follows: $3Cu_2O + 2FeCl = 2Cu_2Cl + 2Cu + Fe_2O_3$.

A similar result is obtained if ferrous chlorid is added to an unfiltered solution of cuprous oxyd in chlorid of magnesium. The suspended hydrate of magnesia in this case liberates an equivalent of ferrous oxyd, which reduces to the metallic state one-third of the dissolved cuprous chlorid, in accordance with the second reaction given above.

§ 6. The reducing power of ferrous oxyd is also shown with cupric chlorid, which is at once converted by it into cuprous chlorid in accordance with the equation, $2CuCl + 3FeO = Cu_2Cl + FeCl + Fe_2O_3$. The further action of ferrous oxyd will, as we have seen, reduce the cuprous chlorid to the metallic state: in fact, $2CuCl + 6FeO = 2Cu + 2FeCl + 2Fe_2O_3$. If recently precipitated hydrated ferrous oxyd or ferrous carbonate be added to a solution of cupric chlorid in the proportions indicated by the last equation, the whole of the copper is separated in the metallic state, mingled with ferric oxyd, while ferrous chlorid is found in solution. The reaction with ferrous carbonate, which requires a gentle heat, is accompanied by a violent disengagement of carbonic acid gas. This experiment is best made by dissolving in water ferrous sulphate and sodic carbonate or sodic hydrate in the proportions required, and adding thereto a solution holding the proper amount of cupric chlorid. Under certain conditions the cuprous precipitate is brownish-black in color, like that obtained by heating ferrous chlorid with cuprous oxyd, but more generally it is of a bright red color, and often coats the glass with a mirror-like film. A warm solution of cupric chlorid with chlorid of sodium at once converts the metallic copper of the precipitate into cuprous chlorid, which is dissolved, leaving behind only hydrated ferric oxyd. When a solution of ferrous chlorid with chlorid of ammonium and excess of ammonia is added to a solution of a copper salt the precipitated films of metallic copper sometimes possess considerable brilliancy and show a bluish translucency. It is to be remarked that although the cupreous precipitate thus obtained is bright red in color, that which is produced by boiling cuprous oxyd with ferrous chlorid is nearly black.

§ 7. It was long since shown by Levol that hydrated ferrous oxyd will reduce cupric to cuprous oxyd, and this, as we have already seen, can separate from its combinations ferrous oxyd,

whose reducing power may be still further exerted upon the cuprous combination thus formed. These facts serve to explain the results obtained by E. Braun (*Zeitschr. Chem.*, 1867, p. 568, cited in *Jahresbericht* for 1867), which were not known to me at the time of making these experiments. He found that by digesting cupric hydrate or cupric carbonate with ferrous sulphate in solution there was obtained a reddish mixture of basic ferric sulphate with cuprous oxyd, formed apparently in accordance with the equation,

$$2FeO, SO_3 + 2CuO = Cu_2O + Fe_2O_3, 2SO_3.$$

This, when boiled with a further portion of ferrous sulphate, became black in color, and from the small amount of oxygen present was supposed to contain metallic copper. By adding a large excess of carbonate of ammonia to a mixture of ferrous and cupric sulphates, Braun succeeded in obtaining solutions in which all the copper was present in a cuprous form, and even in reducing portions of it to the metallic state, a process which we have seen is complete when the requisite amount of ferrous oxyd is brought in contact with the chlorids of copper.

§ 8. In this Journal for March, 1867, page 308, I described briefly the reaction between cupric oxyd and ferrous chlorid, according to the equation, $3CuO + 2FCl = Fe_2O_3 + Cu_2Cl + CuCl$. I was not then aware that the same had been shown by Meyer (Berg. und Hutt. Zeit., 1862, 182, cited by Kerl).* Further studies of this reaction have given me interesting results. The black oxyd of copper, even after ignition, is attacked by ferrous chlorid in the cold, but the insolubility of the resulting cuprous chlorid retards the action. If however the ferrous chlorid be mingled with a strong solution of chlorid of sodium, and heat applied, the cuprous chlorid is readily dissolved, and the reaction is rapid and complete, the whole of the iron separating as a bulky reddish-brown precipitate, provided three equivalents of cupric oxyd have been taken for two of ferrous chlorid. The greenish solution thus obtained readily dissolves precipitated metallic copper, in virtue of the cupric chlorid which it contains, and, unless a large excess of chlorid of sodium be present, deposits white crystalline cuprous chlorid by cooling or by dilution. When digested at a temperature of 50° Centigrade with carbonate of lime, the greenish solution deposits one-third of its copper as a pale green insoluble cupric hydro-carbonate, while the colorless filtrate retains the remaining two-thirds in the form of cuprous chlorid. If a solution of ferrous chlorid with chlorid of sodium is digested with a sufficient excess of cupric oxyd the cupric chlorid formed unites with the latter to form an insoluble cupric oxychlorid, and only cuprous chlorid remains in solution.

* Metall. Huttenkunde, xi, 588.

§ 9. For the ferrous chlorid in the experiments in § 5 and § 8, a solution of ferrous sulphate with chlorid of sodium may be substituted. When cupric oxyd is heated with an excess of ferrous chlorid, a small portion of ferric oxychlorid is produced. The red-brown precipitate may be washed free from cupric, cuprous and ferrous chlorids by a strong solution of chlorid of sodium, but will then yield to pure water a portion of soluble ferric oxychlorid. By careful desiccation in a water-bath and subsequent washing with dilute alcohol the ferric precipitate may be obtained free from chlorid of sodium, and completely insoluble in water; but its composition appears to be variable. Of two preparations the first contained one equivalent of chlorine for eleven, and the second, one for twenty equivalents of iron. In another experiment where fine oxyd of copper from the calcination of malachite was dissolved in an excess of a mixture of ferrous sulphate and chlorid of sodium at a boiling heat, it was found that for thirty equivalents of copper dissolved there were precipitated twenty-one equivalents of iron, instead of twenty as required by the formula given in § 8; the additional equivalent being separated as ferric chlorid in union with the ferric oxyd. The production of a small and variable amount of ferric chlorid in the above conditions is apparently due to a secondary reaction between cupric and ferrous chlorids in the presence of ferric oxyd; $2CuCl+2FeCl = Cu_2Cl+Fe_2Cl_3$. This point however requires further investigation.

§ 10. The facility with which cupric chlorid parts with one-half of its chlorine and passes into the more stable cuprous compound is shown by its well known power to chloridize not only metallic copper, but metallic silver and even sulphid of silver. Its action on cuprous sulphid is not less remarkable. A strong solution of cupric chlorid mingled with chlorid of sodium rapidly attacks pulverized copper-glance, even in the cold, sulphur being separated and cuprous chlorid formed; $2CuCl+Cu_2S = 2Cu_2Cl+S$. Chalcopyrite, on the contrary, is but slightly acted upon by such a solution, which, however, slowly takes up a portion of iron, forming ferrous chlorid with a corresponding amount of cuprous chlorid.

ART. XIX.- *-Notice of a recent Land-slide on Mount Passaconaway*; by GEO. H. PERKINS, Ph.D., Prof. Zoology and Geology, University of Vermont.

THE name Passaconaway is given to a somewhat extended mountain in Grafton county, New Hampshire, twenty miles northeast of Plymouth, and about the same distance southwest of Mount Washington. It consists mainly of three conical peaks of nearly equal height, which form a group at the southern end, and of a high ridge running several miles northeast. A much smaller ridge stretches in a southerly direction. During the great rain of October 4th, there was an unusually large land-slide upon the southwestern slope of the most southern of the three highest summits. The light-colored streak down the mountain side, which marked the course of the slide, could be distinctly seen for more than fifty miles. It was at this distance that I first saw it, two weeks after its occurrence, and with my friend Rev. M. T. Runnels of Sanbornton, set out to examine it. At Campton we were joined by Mr. Chas. Cutter, to whose knowledge of the region and general kindness, much of our success was due. From Campton a ride of ten miles in a northeasterly direction up Mad River valley brought us to Waterville; thence we proceeded on foot. After walking two or three miles we reached a level clearing of fifty acres through which Mad river runs, here only a few yards across. This space was covered with great heaps of logs, some of them very large, brought down from the débris of the slide during the freshet that attended or followed it. That they came from the slide was very evident, for nearly all were broken as if suddenly snapped in two, many had one or both ends crushed to splinters so fine that they seemed like great brushes, and all were entirely stripped of foliage and of most of the smaller branches.

These logs were mainly spruce, and some were fifty to sixty feet long, and one to two feet in diameter. They were piled up in great confusion to the height of fifteen or twenty feet. Subsequent investigation showed that this was at least three miles below the terminus of the slide. Nowhere else was there such a mass of timber as here, nor any where else was the ground so favorable for such an accumulation; for elsewhere the banks of the stream were high and rocky, and not more than eight to twelve rods apart.

The whole mountain is covered to the very top with a forest of spruce, and to reach the slide most easily we followed the bed of the stream along its side. At short intervals were piles of logs more or less broken, by which the stream had evidently been in several places completely dammed.

Trees on the banks twenty feet or more above the water were scarred, rubbed, and even uprooted, by those borne on the current of the swollen stream. A toilsome walk brought us to the foot of the slide which lay directly in the bed of the stream. This side of the mountain is quite steep, and in outline regularly triangular. Its height is about four thousand two hundred feet.

The slide commences forty rods from its summit, and a little to one side of the highest point. At the outset it is very narrow, being not more than a rod wide; a narrow tongue runs above this, however, for a short distance. For fifty or sixty rods the increase in width is very gradual. The inclination is very steep, appearing almost perpendicular and probably not less than fifty to sixty degrees. For the next hundred rods the width increases more rapidly. A hundred and thirty rods from the top the widest part is reached. Here the sides bend gradually outward and the width is twenty-five to thirty rods. From this point the sides begin slowly to approach each other, and thirty-six rods below, a hundred and fifty-six from the top, the width is nearly seventeen rods. The course from the top to this point is in a direct line, but here a curve toward the northwest begins and ends eighty rods below, nearly at a right angle with the main axis. The whole length is nearly two hundred and forty rods, and the outline is fusiform, with the lower end curved to one side. Directly across the line of the main axis a few rods from the foot of the mountain runs a high ridge. Instead of striking this, as would have been expected, the slide begins to turn nearly a hundred rods above, and when within twenty rods is almost parallel with it. There seems to be no reason why sand, rocks and débris of all sorts should not have been thrown against this ridge; indeed there is every reason why they should have been. Yet the space between it and the slide is singularly free from such material. There is undoubted evidence that one or more watercourses ran down the mountain before the slide, and probably did much to cause it. These streams, which form part of the source of Mad river, must have been very inconsiderable, and yet the mass of rock and sand seems to have been guided by them in its downward course. It appears incredible that so great a mass moving with power and velocity enough to snap off hundreds of great trees, crushing many of them to splinters, and piling up such heaps of débris, could be directed by such small watercourses, but the facts indicate it.

There has for a long time, been the track of a former slide down a part of the surface covered by the more recent one, but it was very small. Contrary to our expectations the side of the mountain over which the slide passed, was not bare rock

stripped of surface material. Only in two places, both small in extent, was the rock foundation of the mountain exposed. One of these was at the top where the slide seemed to have started from a ledge, the other was a little less than half-way down, and reached entirely across the track of the slide. With these exceptions the whole surface was covered with a loose, coarse sand or gravel, consisting entirely of comminuted rock, increasing in depth from top to bottom and very loosely compacted. The thickness of this loose material was shown along the sides of several small streams that were running down the slide, which, at the time of our visit, the 20th of October, had cut entirely through it, and ran over the solid rock beneath. Near the top the ground was moist but there were no streams; these began twenty or thirty rods farther down. At the top of the slide, the surface sand was only a few inches deep; below the second exposure of rock it was between one and two feet; at the widest part, a hundred and thirty rods from the top, it was from six to eight feet; a hundred and fifty rods, it was nine to ten feet, and at the bottom fifteen to twenty-five, and in some places, even thirty feet deep. At this point the slide seemed to have suddenly stopped, for there was no gradual diminution in thickness below it.

How much of this coarse gravelly sand originated with the slide, being ground by it from larger rocks; and how much existed before as surface soil disintegrated from the solid rock, I could not estimate. The sand was pure syenite and contained no trace that I could find, of any vegetable mold. From an examination of the banks of Mad river below, and of the soil by the side of the slide, I am convinced that the greater part was produced by the disintegration and falling to pieces of the mountain's rock, and so existed before the slide, and was carried along and heaped up by it. The mountain is, so far as I could learn, wholly composed of light gray, rather coarse syenite, which appeared to disintegrate very readily, as I saw large masses that could easily be pulverized. A mile below the slide there were extensive layers of black hornblendic rock, and in one place the syenite was crossed by trap dikes, from an inch to a foot in thickness. Some of these dikes forked several times, others crossed each other in the form of a letter X, and some varied greatly in thickness along their course. A few broken crystals of rose-purple quartz, an inch or more in diameter, were found among the débris. But the only rock in place along the course of the slide was the syenite.

Scattered all over the surface of this loose, sandy material, were masses of syenite, of various sizes though none were very large. These were angular, and appeared to have been recently broken. They were undoubtedly fragments of large

masses broken by the slide. Besides these, there were a few well worn boulders of syenite, quartz, and hornblende rock, some of which were near the top.

All the trees that had stood on the ground now occupied by the débris of the slide, were carried away or buried up, only a very few bare logs remaining in sight.

Along the sides of the slide the forest was full of uprooted, bruised, and broken trees.

The upper part of the slide was much more rugged and covered with a greater mass of broken rocks than the lower. Over the widest portion there were few rocks on the surface, which was smooth and level as if rolled. Below this it was rougher but not as much so as above.

The appearance of the surface was the same in all parts. Its color was a light yellowish brown, and at a little distance it closely resembled a field lately ploughed and harrowed.

It is the contrast of light color with the dark green of the spruce forest around it that causes the slide to be so distinctly visible at long distances. As is stated above, the upper portion of the slide is very steep, but after the first fifty rods the angle of inclination is less, and just above the widest part it is not more than twenty-five degrees. Below it is not more than fifteen degrees.

ART. XX.—*On the Silver Mines of Santa Eulalia, State of Chihuahua, Mexico*; by JAMES P. KIMBALL, Ph.D.

THE silver mines of Santa Eulalia were among the earliest mineral discoveries of the Spaniards in Northern Mexico. Don Jesus Inocente Irigoyen of Cusihuiriachic, a good antiquarian authority, states that the year of discovery was 1591. The only available official register of their performance, however, goes back no further than 1705, but mentions their discovery in 1703—twelve years after the city of Chihuahua was founded, according to the date given by Dr. Wislizenus. From 1705 to 1737, they produced 6,583,500 marcs, or an average of 1,938,903 dollars of silver per annum. Up to 1791, during a period of eighty-six years, their acknowledged production of silver, of which the *quinto*, or king's fifth, was paid to the royal exchequer, was 11,903,126 marcs, or nearly *one hundred and twelve millions of dollars*, and their entire production from one-fifth to one-third more. At this period the district had a population of 6000, and supported sixty-three reduction establishments with one hundred and eighty-eight smelting furnaces of

the type known as the Mexican *horno*, and sixty-five cupelling furnaces; while a number of similar establishments in the city of Chihuahua were also kept running on ores from this district. The depredations of the savages, which until comparatively quite recently have always seriously interfered with industrial pursuits in Northern Mexico, became so grievous during the last five years of the past century that the district was gradually abandoned.* Indian hostilities were soon followed by political troubles, including the war with Spain and the proscription of the Spaniards. During the present century, operations at the hands of the Mexicans have never been fully resumed. Yet shallow workings have continued to furnish ores to a small number of furnaces, which to a considerable extent have also made use of the débris of former operations. At present ten blast furnaces, each of a capacity of 2500 to 3000 lbs. of ore per day, are in operation, their small supply of ore being drawn from the older as well as the newer mines. The fresh ore from the mines as charged to the furnace, is eked out with the settlings of the old slag heaps, and coarse refuse from old workings, extracted from the dry bed of the creek which in time of rain courses through the mining village of Santa Eulalia. As in old times, for the sake of mutual protection, the reduction works of the district are still all collected here, along with the dwellings of the miners and smelters, who number with their families some 700. Recollections with the old, and traditions with the young, still fill the minds of the dwellers in this narrow valley with dread of the Apache, who even now is occasionally found lurking among these mountains, and of whose hiding all have been taught to be wary when moving about alone.

The village of Santa Eulalia is fifteen miles east of the city of Chihuahua, across the expansive champaign valley of Tabalopa. This city, the capital and social center of the state of the same name, and containing some 20,000 inhabitants, attained its importance mainly through the silver industry of Santa Eulalia, in the period of whose prosperity it had a population of 70,000. Chihuahua afforded—what have ever been lacking at Sta. Eulalia—water and space for the dressing and reduction of ores; and to the city therefore was brought and smelted a large portion of them. Immense heaps of slag, twenty in number, on the outskirts, attest the extent of work done there during the last century, while the imposing, and in some respects admirable, cathedral of the city is a monument to the mines of Santa Eulalia, it having been built out of a fund raised by the tax of one real per marc of silver coined,

* Manuscripts and certificates in No. 65, folio 26, state archives. See also Ward's Mexico, 1st edit., vol. ii, p. 129, (2d edit., i, p. 454).

and which, continued for sixty-two years, ending in 1789, amounted to 800,000 dollars.*

The Sta. Eulalia mountains are a portion of a long range trending N.E.—S.W., one of a system of parallel ranges, which, separated by champaign valleys or valley-plains, characterize the topography of the sloping margin of the Grand Sierras, and as much at least of the state of Chihuahua as lies north of the 28th parallel, and east of Concepcion—beyond which limits my experience does not extend. The range lies between the broad and fertile valley of the Conchos on the east, and the narrower valley-plain of Tabalopa on the west. Access to the village and mines of Sta. Eulalia is from the latter. The village lies two-and-a-half miles from the plain up the mountain stream of the same name, at the foot of the higher hills, in which, at distances of two to five miles, the mines are situated, and which are crossed only by bridle-paths.† The mining ground is embraced within the area of an uplift of the Cretaceous fossiliferous limestone, imparting toward the center of it gentle quaquaversal dips. This is a prolongation of the narrow continuous elevation of this formation, reaching to the Rio Grande in an axis parallel to the Conchos river, and a part of the same formation which in Texas comes to the surface in the Rio Grande basin, at least, between the 28th and 31st parallels, except in mountainous localities, or in the case of stratigraphical depressions, where an upper and metamorphosed member of the same formation (a porphyritic quartzite) known in Mexico as *cantera*, caps the summits.‡ In Mexico, under similar conditions of superposition of the latter, the

* State archives. Ward erroneously states this tax to have been collected during nine years pending the last *bonanza*, ii, p. 581. (2nd edit., p. 305).

Accustomed, as of late, we have become to the far higher returns of not larger groups of silver mines, it is easy to pass over the full significance of the comparatively low figures of early operations in northern Mexico, unless we are mindful that it is to the availableness of mechanical appliances, that our great production of silver is more to be ascribed than to the number or superiority of recent discoveries. What account of the Comstock lode by this time should we have were its mines, as in the case of those of northern Mexico during the period of their activity, without other than the rudest iron or steel implements, without powder, except in rare cases of a foreign stinted supply, with only the *adobe horno* for smelting, and the little *cazo* for amalgamation; and continually harrassed by Indians? Although supplies are no longer quite out of reach, the mines to-day are worse off than during the last century, for most of them have reached a point where have become necessary mechanical appliances, with which the Mexicans are entirely unacquainted. They continue to suffer the want of what *adobe*, raw-hide, and wood will not supply, following the practice of the Spaniards, which in their hands has rather retrograded than advanced. The silver industry of Chihuahua at present amounts to little more than cleaning up the rubbish of former workings.

† For a popular and graphic account of this picturesque mining district, see an article by Gen. Lew. Wallace in Harper's Monthly, Nov., 1867.

‡ See notes on the Geology of Western Texas and Chihuahua, by the writer, this Jour., xlviii, p. 378.

Cretaceous fossiliferous limestone, with local lithological differences, is the prevailing formation of the Rio Grande and Conchos basins, where, as seems likewise to be the case in Texas, within the development of the cantera it sustains throughout a metalliferous character. The mineral deposits of Sierra Rica, Cuchillo Parado, the Chupaderos, and the Chorreras in Chihuahua are all contained in it. In the Santa Eulalia mountains is its most westerly development in any great prominence above the valley plains, though seventy-five miles still further west, a limestone is said to form the low base of the Sierra de Magistral, where it is likewise metalliferous, and where, going west, it is last seen. In the Santa Eulalia mountains, the same as in other localities named, the *cantera* caps the higher elevations. This name is applied in Northern Mexico to the bleached portion of an essentially alumino-siliceous rock, generally more or less metamorphosed and ferruginous, and occurring in a great variety of colors.* As elsewhere explained, it is to the disintegration of this rock that the accumulation of soil in the valleys is due, as well as their peculiar conformation.†

Allowing for erosion, the mines of Santa Eulalia may strictly be said to be grouped in a single great boss of the Cretaceous limestone strata, gullied or scored by water-courses which impart to all portions of it a rugged and precipitous configuration. There, as elsewhere throughout the development of the fossiliferous limestone, the water-courses have cut bold, almost perpendicular, escarpments in which the stratification is very plainly marked. In this district the dips are from 5° to 15°, and from a point near the Vieja mine are quaquaversal. The ravine, Arroyo de Dolores, which takes its name from the old mine of Dolores, at its head, has been cut through the crest of the limestone uplift, and thus exhibits in steep mural escarpments a partial thickness of the formation of 400 to 500 feet. Its true thickness, however, has never been revealed. The oldest and most extensive mines are in this ravine, including the deep ones of Dolores, Vieja, Aguada, and the shallow or cavernous workings of Parcionera, San José and San Matias. The distance of Arroyo de Dolores from the village is some three miles, horizontal, from four to five topographical.

As the limestone uplift or boss expires, the summit cantera, a few remnants of which cap the limestone hills, sets in, and within a couple of miles, becomes the main formation, and forms the body of the range. No limestone appears in the Puerto de Dolores, seven miles to the north, where the San Diego and Chihuahua road crosses the Sta. Eulalia range; and in the village of Sta. Eulalia, it has already declined below the surface. The overlying cantera presents a greater development

* This Journal, xcviii, p. 380. † Ibid, p. 381.

in the surrounding hills, which rise to the height of some 800 feet above the plain.

A curious lithological phenomenon, though in a less conspicuous way not uncommon in other localities which I visited in Chihuahua, is a formation of conglomerate which is found on all the slopes of the district, and which incases the lower and middle portions of the hills like a shell.* This has evidently been formed by carbonated calcareo-magnesian infiltrations, springing from the summit cantera; and, penetrating the fine and coarse detritus of the surface alike, have cemented it, and thus produced all the gradations from a fine friable sandstone to a coarse breccia. The village rests upon it. In the main street it is distinctly bedded, and cleaved by joints. Nowhere is it found entering into the interior structure of the hills, and no traces of it are found in steep places. Yet cursory observation might dispose the traveler to assume the main body of the mountains to be made up of this formation.

The mineral deposits of Santa Eulalia are unique. The only instance of a vein formation brought to my notice in the region is in the Santo Domingo mine. All the rest of the deposits are more or less irregular, and in a variety of modes of occurrence, are contained in the nearly horizontal fossiliferous strata (Cretaceous). All the strata above water level are exceedingly cavernous. In nearly all of the workings, caves, entirely shut off from the surface have been encountered. Some of these are of enormous size. The great cave of the Parcionera and San José mines, is said to be large enough to hold the cathedral of Chihuahua. Though unable to explore its height, or to illumine its roof, I am disposed to believe this. Drusy cavities or vugs of all sizes, are the smaller exhibitions of the same prevailing cavernous character. These latter yield excellent pockets of ore. Rich *bonanzas* have been got from chambers in the walls of the large caves. The ores which are mainly the chlorid and sulphids of silver, argentiferous galena and salts of lead, together with, (though of rarer occurrence,) the chloro-bromid (embolite) and iodid (iodyrite) of silver, are very ferruginous, to which circumstance they owe their friable character, and also, to a considerable degree, the spaces in which they have been deposited. Courses of ore are always marked by ferruginous stains, which, properly considered, are segregations of mineral matter, sometimes following cleavages and joints, and sometimes planes of bedding, and, again, sometimes reticulating solid beds, and in all these modes of occurrence, without order or defined limits. A bed, or a number of beds, of the limestone, in places may be thoroughly webbed with such segregations of so decided a character as to

* This Jour., xlviii, p. 382.

impart a concretionary appearance, or, as if limestone breccia were cemented by ferruginous ore. In such places the beds, are *not* brecciated, but thus strikingly indicate the energy of disintegrating and segregating action under the decomposition or oxydation of iron salts (probably proto-carbonate) originally contained in the limestone, together with diffused salts of silver. These ferruginous portions always afford good mining ground. As some of them are very extensive, and as their distribution is irregular, their excavation results in large and rambling chambers, generally ranging through a number of the heavy beds of limestone. Such chambers are often continuous with natural caverns, together forming underground spaces scarcely less imposing than the most noted caves that excite the wonder of tourists.

The mines of Santa Eulalia are scattered all over the great limestone uplift, and along the deep ravines which have scored it. All are comprised within an area of some five square miles. In the hillsides they consist mostly of horizontal workings, and occupy different strata from top to bottom. Shafts and deep workings, which are few and ancient, are located both in the hills and ravines. Accessibility of the mines is determined by the topographical configuration of the mining ground, the primary form of which, before modified by erosion, it is important to keep in view. As they are reached from the village by three different trails, I will describe them in as many separate groups, as follows: the *Santo Domingo group*, comprising the workings in the same cañon as the Santo Domingo mine, and of which this mine is the principal; the *Dolores group*, or those in the cañon, at the head of which is the old Dolores shaft; and the *Guadalupe group*, comprising the workings on the summit and S. W. flank of the limestone ridge, which forms the divide between the Dolores Cañon on the northwest, and on the southeast—the waters of the *arroyo* in which is the village of Santa Eulalia.

Santo Domingo Group.—The Santo Domingo and neighboring mines are two miles north of the village, up near the head of a deep ravine, in both sides of which, at different elevations, they have their entrances. As this locality is about one-and-a-half miles to the southeast of the axis of the boss, the dip of the formation is seen rapidly declining in the ravine toward its mouth, and the overlying cantera is thus brought down so as to form the body of the hills. The limestone altogether disappears from above the bed of the ravine within a few hundred yards south of the Santo Domingo mine, where the cantera sets in and forms the surface. The town is really on the horizon of this formation, though the surface is immediately overspread by the cemented rubble above described. The hills on either

side of the defile in which the village is situated, rising as they do some 700 feet above it, are both topographically and stratigraphically the highest elevations in the district. They are made up wholly of cantera distinctly and nearly horizontally stratified, and in different zones weathering with a variety of colors. They have mesa tops, and present to the broad valley-plain of Tabalopa bold escarpments flanked by low foot-hills.

The *Santo Domingo*, old and present, are deep workings entering the limestone boss on the west side of the ravine. The old mine, now abandoned and dismantled, consisted of a shaft located so high on the hillside that it must have pierced one hundred feet of cantera before striking the limestone. The present mine is some 500 yards further up the ravine, and, at an elevation above its bottom of some 120 feet, goes down in a bed of fossiliferous limestone some 30 feet from the top of the formation, the division being plainly indicated by a ledge of cantera above the entrance of the mine. Its depth is about 400 feet. This is reached by an irregular descent, the only thoroughfare, in which passage is laboriously effected partly by means of ladders, and partly by footholds in the rock. This main-way occupies a vertical crevice in the limestone, or a series of cavernous partings more or less filled out with workable ores. The widest portions are some 12 feet, the most contracted, not more than six inches. Many of the former are of the nature of drusy cavities lined with quartz and gypsum. The narrower portions have generally yielded paying ore of a decomposed and ferruginous character. The vertical crevice, which has been followed westerly into the hill has been pretty thoroughly wrought. The most extensive workings, however, follow rich partings between planes in the limestone beds, thus giving rise to lateral excavations opening into the main-way. Rich pockets of galena are found both in the crevice and in the horizontal deposits, and these seem to be increasing in depth. Indeed it is chiefly for galena and other plumbiferous ores (*plomosos*), that this mine is at present wrought; and it appears that its ores of all grades (*ayudas*) have always been prized less for their argentiferous qualities, than for the property of facilitating the smelting of the more refactory ores (*resecos*) of the district.*

* Although over 300 feet below the bed of the ravine, which is dry except in the rainy season, there is no water, or even sensible moisture in the bottom of the mine; and though the deepest mine at present wrought in the region, it is, like all the others, without mechanical appliances of any sort. The ore is spalled underground and brought to the surface on the backs of men and boys whose burdens vary from 100 to 125 lbs., and who make during the day five trips to the bottom. The mine is so excessively warm and badly ventilated as to be almost suffocating; while its passages are so worn and polished by the hands and feet of the miners as to afford the most precarious footing. The carriers (*tenateros*) are surprisingly muscular, nimble and sure of foot, running with swiftness up and down the single

The other workings of this group are on the east side, and further toward the head of the ravine, occupying different beds in the limestone and pursuing productive courses of ore. The principal are *Chiquihuite*, *Rosario*, *Gertrudis* and *S. Lazaro*.

DOLORES GROUP.—The cañon of Dolores is a deep gorge cutting almost perpendicularly the axis of the limestone uplift or boss. The cliffs thus formed, expose on either side a perfect section of bare limestone strata. Its course is very nearly westward, and its head opposite and very near that of the Santo Domingo arroyo. Together the two water-courses describe a triangle, and as they border the mining area impart this shape to it. A lofty ridge capped with the summit cantera divides the two waters. Owing to the comparatively rapid declination of the limestone strata in this direction, the workings toward the head of the cañon are by means of shafts going down just above its dry bed. They are the Tiro Dolores, present Dolores, the "Gauo" (Aguado) and the Vieja shaft.

The *Tiro Dolores* is a vertical shaft starting in the cemented rubble, but soon striking the fossiliferous limestone which, from 200 to 300 yds. below, is uncovered in the bed of the cañon. The shaft is 327 ft. vertical—at which depth a slanting passage, now flooded with rain-water, carries it some 100 feet deeper.

The *Aguado*, like the Dolores, is now inaccessible. It is an irregular sinking of about the same age and depth as the latter, and communicates with it by deep workings. Its mouth is near the top of the limestone formation.

The *Dolores*, present working, is a sinking of the same description as the Aguado, with the lower workings of which, and thereby with those of the older Dolores, it connects. The upper and more accessible workings are still wrought in a small way for plumbiferous ores. The *Vieja*, some 200 yards still further down the arroyo is also an irregular sinking carried to the depth of about 165 ft. It still affords desirable silver ores.

All these mines were formerly diligently wrought—the shafts by means of horse-whims. From a watch-tower on the highest point overlooking the whole district, timely warning of the approach of the savages could be given. Ruins of stone dwellings built strong for defense, indicate a former settled establishment in the bottom of the defile, which, as in the case of all the others in the region, contains water only during rains. The water in the mines appears to have got in from the surface, no percolation being sensible even in the deepest.

In the immediate vicinity of these old workings, near the

notched stem of a ladder, and the shelving, slippery rocks in lieu of steps, but laboring for breath, and their bare bodies bathed in perspiration. No laborers in the world have a more arduous task. The cost of raising the ore in this manner is 25 cents per 350 lbs. This could be greatly reduced, and the mine improved by an opening from the ravine.

head of the arroyo, the dip of the limestone beds to the southeast is near 45°. The vertical axis of the boss is in the eroded neighborhood of the Vieja, at the confluence of another arroyo from the southwest. From this point in every other direction the dips (quaquaversal) are gentle, coming down gradually to not more than five degrees. But the steeper dips toward the outside of the limestone boss have brought up a great thickness of this formation (400 ft.) above the arroyo, and thus west of the Vieja the same strata are above its bed, as could only be entered by shafts east of this point. This is an explanation of the fact that below the Vieja all the workings are above the bed of the ravine, their openings being in the bluffs. These workings are all approximately horizontal: that is, they follow the stratification which on either side being slightly inclined *from* the ravine, gives them all something of a descent *into* the body of the hills.

The *San José* enters the south bluff a quarter of a mile below the Vieja, some 30 ft. above the bed of the arroyo. Its workings extend to several beds, the excavation of which has caused great chambers, while a number of natural caves also have been opened. The ores here are mainly diffused through the limestone strata in ferruginous and the more decomposed portions. They are also found in courses leading from stratum to stratum, but never in the form of a vein.

The *Parcionera* opens near the San José some 70 feet higher up the bluff—its workings, however, descending so as to connect with those of the latter, and thus excavating several beds. It may be described as a series of caverns, both natural and artificial, the largest in the district. It is here that is to be seen the immense one already mentioned. The openings extend about 500 yds. into the hill, in which distance they fall some 150 ft. The pursuit of courses of ore whither they might lead, has caused very irregular passages. The ores of the mine are highly prized, and at the time of my visit were being extracted by twenty miners for the supply of the furnaces of Don Emanuel Escobar. The ores then coming out were plumbiferous. Their mode of deposit does not differ from that of the San José ores.

The *San Matias* is in the north bluff, directly opposite to the San José and Parcionera, and going in on the same level. It is one of the more cavernous, as well as one of the largest and oldest, mines in the district, having been wrought southeastward so as to connect by descending passages with the workings of the Vieja, a quarter of a mile off. It is still wrought by Mateos & Co. Its ores are excessively ferruginous (*colorados*), their color being that of red hematite. According to the owner they are now yielding 12 ounces to the carga ($103 to the ton.)

Several openings in the north bluff have been made at higher levels. One, the *Cuartillera*, is at the height of some 300 feet above the bottom of the cañon. It furnishes a non-ferruginous ore of a drab color.

GUADALUPE GROUP.—It is convenient thus to designate the numerous workings in the same hill with the Parcionera, situated, topographically speaking, some above these mines, and some on the opposite north and west sides, wherever the surface is not too steep to afford easy access.

The *Guadalupe* mine is directly over the Parcionera and San José, and opens from the plateau which marks the top of the limestone formation. Its workings progress southeasterly, descending through several very ferruginous beds in which silver ores seem to be concentrated in "pockets"—the average ferruginous courses being filled with segregated quartz, and generally barren. A drusy cavity is said to have been struck here in 1865 which gave in one day sulphids of silver worth $5000; and five months afterwards another, yielding $1200.

The *Aragon* is a similar working in still higher limestone strata, and very near the junction of this formation with the cantera, here a buff, porphyroidal quartzite, a fine outlier of which rises some 150 ft. above the limestone plateau. Both this mine and the Guadalupe steadily yield plumbiferous ores, carrying, mostly in an invisible form, chlorid, bromid and sulphids of silver.

The other mines of this group are all on the left flank of the limestone ridge. They are the Santa Rita, San Francisco, Purisima, Negrita Grande, Negrita Chiquita, and the Carmen.

The *Santa Rita*, one of the oldest and more reputable mines, is a shelving excavation, starting in fossiliferous limestone, some 350 ft. above the bed of the Dolores arroyo. A large burrow of ferruginous material indicates the extent of former workings. The main opening is said to be asphyxiated, and is now closed, though containing, according to all accounts, ores running as high as four marcs to the carga ($250 to the ton).

The *Purisima*, occupies nearly the same level as the Santa Rita, going down some 60 ft. in heavy bedded limestone, fossiliferous at the surface. The fossils, as usual in this locality, are a coral, *Radiolites*, and fragmentary *Pecten* and *Inoceramus*. The mine, though now vacant, was worked three years ago, and is said to have proved satisfactory.

The *San Francisco* is a sloping excavation in the hillside, and some 100 ft. lower in the limestone than the Santa Rita. The workable portions of the limestone beds closely resemble those of the workings in the Dolores arroyo. The mine is now supplying highly prized ores to the Chihuahua Company's hacienda.

The *Negrita Grande* is an old, now inaccessible, shaft, more

than 250 ft. deep, which depth about corresponds to the level of the arroyo immediately below the mouth of the mine, and from which it would be practicable to reach its workings. The shaft was formerly worked by horse-whims (*malacates*)—probably by the distinguished Bustamente who is reputed to have had a *bonanza* from it of $60,000, said to have been in the form of concentrated chlorid of silver.

The *Negrita Chiquita* is a newer open working, now operated by Don Jesus Mateos, and occupying strata but a little lower than the mouth of the shaft of the *Negrita Grande.* The *Carmen* occupies beds somewhat higher, and is a similar cavernous excavation.

It will be understood that notwithstanding wide differences in topographical level, all the workings above mentioned are embraced within the same set of beds whose combined thickness does not exceed 450 ft.; that the shaft workings at the head of Arroyo de Dolores, the mines of the Santo Domingo arroyo, and the workings on the top of the plateau forming the surface of the limestone uplift, *all have their entrance at about the same stratigraphical horizon; that is, near the top of the limestone.* And it is to be borne in mind that stratigraphically the lowest workings are *not* those which topographically are the lowest, but the San José and San Matias instead of the Dolores, Vieja and the Aguado.

Notwithstanding the number and size of the excavations in the mining ground of Sta. Eulalia, and the large returns which these have afforded, its future prospects seem scarcely impaired by the achievements of the past. By the modern scale of mineral industry, these might pass for only a thorough exploration—in its assurances worth all that it has yielded. The location of the mines has been determined by the accidents of the surface rather than by promising outcrops—a foothold upon the surface seeming to have been all that was necessary. Besides the great amount of unbroken ground left in and amidst the established mines, a large body of the limestone strata remains untouched, especially to the north of the Dolores arroyo, where the inner ends of the workings, proceeding from the bluff on that side, show no deterioration or diminution of the ores. It is not venturing too much to predict that the past record of Sta. Eulalia will be far surpassed at some future time by its development prosecuted by an enlightened practice.

Yield.—Extracted according to the judgment of the miners who are very expert in the detection of familiar ores, the ores after being spalled, run from 4 to 6 oz. to the carga ($34·46 to $51.60 per ton of 2000 lbs.) Four-ounce ores are abundant in all of the mines, but scarcely pay for working by the present smelting practice. By care in selection, this grade is easily

brought up to five and six ounces to the carga. This is the lowest working yield of all the smelting operations—the average being something above this. Don Jesus Mateos, one of the most experienced operators in the district, by using a mixture of the 12 oz. ores from the San Matias and 6 oz. ores of the San José, obtains never less than 6 oz. to the carga, generally as high as 8 oz., and sometimes 9 and even 10 oz.

Cost of ore.—The cost of ore delivered at the mouth of the mine varies according to the expense of raising. At the Parcionera, which may be taken as the type of horizontal or sloping workings, this cost, which includes all mining expenses, is stated at $1.50 per carga. At the Santo Domingo, the cost is greater on account of the laborious raising. The ores are delivered at the furnace for 20 to 37½ cents per carga, the donkey-load being one carga (300 lbs.)

Reduction.—The furnace employed in the district is the common Mexican *adobe horno*, a blast-furnace 47 inches high, 18 in. wide at the top, slightly tapering toward the bottom, and 16 in. across. The blast is supplied by hand bellows, the nozzle of which is in the back, 8 in. from the bottom. In the better constructed establishment of the Chihuahua Co. the bellows are set in motion by mules. The charge of the furnace varies according to the notion of the smelter as to the requirements of the different ores. Mateos uses 75 lbs. of spalled ore to 20 lbs. of litharge, and 12 to 25 lbs. of old slag (*grasa*) by way of flux. The charge of litharge varies with the ore. Plumbiferous ores, like those of Santo Domingo, Santa Gertrudis, Dolores and San Antonio, give an excess of litharge, and hence are in especial favor for mixture; while the excess of litharge obtained is sold out of the district at the rate of 8 to 16 dollars per carga ($2.67½ to 5.32½ per cwt.) The cupellation is done in the ordinary *adobe vaso*, one serving three blast furnaces, or treating 20 cargas of argentiferous lead per week.

Fuel.—The question of fuel is one of paramount importance to the industry of the district. The *mesquite* root is the only indigenous fuel of the immediate section of country, forest trees being entirely unknown east of the humid belt, 50 miles to the west of Sta. Eulalia, except the cotton wood (*alamo*) which is cultivated for shade. Yet nothing could excel this root as a fuel, either as it comes from the ground, or after conversion into charcoal. A single shrub generally gives near a cord of heavy root. In the neighborhood of Sta. Eulalia, the *mesquite* has long been exhausted by the draft upon it from there, and from the city of Chihuahua. Oak charcoal is brought 30 leagues to Sta. Eulalia from Mapula, and sold at the rate of 75 cents to one dollar per quintal (100 lbs.)—the lower price prevailing whenever the roads are favorable. Oak wood is likewise brought thither, and

sold at the rate of one dollar (copper) per carga (80 sticks, 28 by 4 in.). The same prices prevail in the city of Chihuahua. Mes quite charcoal from the east side of the Sta. Eulalia Mts. is delivered at the village for $1 to $1.50 (copper) per quintal. These prices, already high, would doubtless steadily advance under a larger and more pressing demand, such as would be created by an extensive smelting industry depending upon a *certain* supply and *limited* price of fuel, without control over either.*

With a cheaper mode of reduction, the cost of production would be very considerably lessened by rendering available ores which, though cheaply and largely broken, are now rejected —ores yielding as high as $34 to the ton. This condition, rather than the introduction of mechanical appliances, would necessarily bring this cost below the cost of extraction of silver ores from expensive workings in Nevada, though now far exceeding that of most of the deep mines of the Comstock lode. But the cost of reduction is even more excessive and out of proportion to the value of the ores. Though the Mexican smelting practice is attended with a smaller loss of silver, the fact that Nevada ores returning no more than $15 per ton can be worked by amalgamation with some profit, more than offsets the loss of 20 to 25 per cent to which all are subjected, as a large and regular business generally depends upon the availableness of the ores of low grade—always predominating in extensive deposits. Yet the Mexican furnace by no means extracts the whole of the silver as may be seen by picking up from any ancient or fresh slag heap fragments containing numerous globules of argentif-

* Expressing in familiar units the above rates imparted to me by Don Jesus Mateos, we have in a form for comparison with working results elsewhere obtained by different modes of reduction the following exhibit:

Cost of Production.

Cost of ore at mouth of mine, per ton, at $1.50 per carga,	$10.00.	
Transportation to furnace, " " 0·37½ "	2 62½.	
		12.62½

Cost of Reduction.

Charcoal in blast furnace, per ton of ore, at $1 per quintal,	$10.62½	
Wood " *vaso*, cupelling, " " " $1 per carga,	2·66⅔	
2 Smelters at $1. per diem, 1 Refiner at 1. " 6 Helpers at 0.37½ " } Labor,	4.92	
Litharge, repairs, etc.,	1.00	19.21½
Total cost of production and reduction,		$31.84

Having adopted the mean of variable rates, no allowance is made for the discount of copper currency (at the time of my visit, in the winter of 1869—33⅓ per cent; but now much greater) in which are stated the prices of fuel, especially as the above exhibit bears out the representation of Don Jesus; namely—that in the failure of the 50 cargas of ore smelted weekly by one furnace to yield a total of thirty marcs of silver, that is (taxes paid) $32 per ton, loss is incurred.

erous lead, and otherwise indicating imperfect reduction. Fuel is far more costly at Virginia, Neveda, than anywhere in Chihuahua, but this difference follows from the higher price of labor there—the supply of fuel really being greater than at Santa Eulalia.*

Thus will be seen the mistake of treating the ores of Santa Eulalia by a practice which is so costly as to render unavailable the great bulk of them, and to absorb almost the whole value of even the choice ores in their reduction, when by a cheaper practice the whole run of the ores could be treated with profit, and the industry improved and expanded in all respects. I allude to amalgamation as practiced in Mexico itself, and which the climate, labor and facilities of the country especially favor. In 1846, it was estimated by Mr. John Phillips, seven-eighths of the silver produced in Mexico was obtained by amalgamation.

The lack of surface for *patios* at Sta. Eulalia, together with the scantiness of water, are circumstances sufficient to account for the prevalence there of smelting, notwithstanding the ores are of a nature to yield readily to patio amalgamation. That these difficulties have never been surmounted is to be ascribed to the isolated condition of this section of country, and its lack of facilities for extralimitary supplies. In the last century, during the period of its prosperity, as I learn from a manuscript in the state archives, amalgamation both by *patio* and *cazo*, was carried on at Sta. Eulalia and Chihuahua to the extent of keeping in operation in the two places 72 drag-mills (*tahones*), and 6 stamp-mills (*morteros de agua y caballerias*). The reduction works, just erected, of the new Chihuahua Co. have not in the least departed from ancient models. Nor would a change of practice be warranted by anything short of an extensive undertaking. In view of the scarcity of water and fuel at Santa Eulalia, it must be seen that present operations without modification can scarcely be extended beyond their present scope. As long as they are thus limited, they are favored by the choice of ores, and by cheap labor. By dispensing with mechanical appliances for dressing ores any considerable outlay is avoided.

The silver deposits of Santa Eulalia, however, are so superior and extensive as to warrant their extraction and reduction on a

* Notwithstanding the rates of labor in Nevada are more than treble those of Santa Eulalia, the ores of the Comstock lode are extracted for a half to a third less, and reduced for less than a half cheaper—their average yield ranging in different mines from $28 to $43. To properly contrast the wide difference between the economical conditions of the industry taken as a whole in the two localities of Sta. Eulalia and Virginia City, it is necessary to consider that of the latter as involving an immense outlay for milling and deep mining, altogether beyond the requirements of the former locality. It is also obvious that a high cost of fuel would, the same as at Santa Eulalia, preclude the practicability of working by smelting any but *selected* ores, and thus confine the Comstock industry within comparatively narrow limits.

large scale. This will be practicable by having recourse to the facilities afforded by one or both of the two plains on either side of the Sta. Eulalia mountains.

West of the mountains, superior facilities for the dressing of ores, and for patios, are to be had at Tabalopa on the Sacramento river, at the distance of some eight miles from the mouth of the Arroyo Dolores. Ores could be delivered at this point by wagon at near the same rate that they are now freighted on mules over the mountains to Santa Eulalia. This way out to the plain would be by the ravine, and thence the whole way to Tabalopa by a down grade.

Having extended my observations but a little way east of this gorge, I am not prepared to determine the question of an exit on that side of the Sta. Eulalia range. Should it be found practicable to cheaply deliver ores in the Conchos valley, this side would, on the whole, present superior conditions for reduction works, provided a good water supply can be had, which is probable, as the plain is already thoroughly irrigated. Fuel (mesquite) is far more abundant here than on the Chihuahua side, and the position is nearer by two days to all supplies drawn from Texas.

New York, Jan. 1, 1870.

ART. XXI.—*Machinery and Processes of the Industrial Arts, and Apparatus of the Exact Sciences;* by FREDERICK A. P. BARNARD, LL.D., United States Commissioner to the Paris Universal Exposition.

IF the imperial decrees of June, 1865 and subsequent dates, which gave origin to the Paris Exposition that opened on the first of April, 1867, were grand and comprehensive in their scope and intention, they were equally illustrious in the success and completeness of their execution. More than fifty thousand exhibitors brought together on that occasion several millions of objects, all different and all deserving attention. These were gathered from some forty nations and countries, covering the entire civilization of the globe. Taken together they formed a representation of the art, the industry and the inventions of mankind, and of every ideal yet realized for the comfort, the elegance, the operative power, and the progress of the human race. From the material to the implement the completed structure or the machine; from the staple to the fabric; from the massive and gigantic—the products of Cyclopean forges or Titanic engines—down to the infant's toy and the gossamer vestment; from the ponderous gearing to the tiny time-piece all were

spread out, an accumulation of series upon series, and every series showing an almost complete and continuous gradation.

The field of the Exposition was the parade ground, or Champ de Mars, easy of access, and supplemented by annexing the island of Billancourt in the Seine, together comprehending an area in excess, by a few acres, of one-fourth of a square mile. Spacious grounds outside the building, or *palace* as it was called, but without much very palatial in its aspect or construction, were allotted to 'structures that ranged from the nomadic hut of an Esquimaux to the gilded palace of the Sultan,' and to such living, or agricultural, or other objects and groups, as could not suitably be admitted within. In deference, we suppose, to French propensities, the number of groups was just ten; but, by a marvellous aberration, the number of subdivisions or classes was but ninety-five. Seven of these so classified groups were arranged in seven oval galleries, one story high, successively surrounding one another, and divided systematically into commodious apartments, the entire assemblage of which comprised an area of forty acres and a circuit of almost a mile. In the center was a pavilion holding sets of the various national coins, weights and measures, and surrounded by a florally ornamented space from which sixteen avenues radiated to the outer space or circumference of the palace. In the sixteen sections thus formed the various nationalities had their products and groups arranged in a series, and all the series corresponding to one another from circumference to center. By passing around the galleries the spectator would come in succession upon similar groups of the different nationalities; while by passing along the avenues he would take successively the various groups of any and every nationality, each through its own entire series. Accordingly a tour of ten miles judiciously disposed, was enough to bring to an observer's attention the entire aggregate of groups within the building. By such means therefore, the best practicable facilities were supplied to each nationality to exhibit its own products to advantage, at once in union and in comparison with the like of other countries, while also the one 'special jury' and the ninety-four 'juries of classes,' for awarding testimonials and degrees of merit—the *prizes*, the *medals* and the *honorable mentions*—and, with them, the ten 'juries of groups,' for revising these awards under the final revision of a 'superior council,' all had the most ready and commanding observation of the objects composing the entire exhibit.

Were it a possibility to continue in permanence such an exhibit—a single area into which all the national arts were gathered and concentrated, like differently colored lights in the focus of an object-glass—there might thus be afforded to visitors

an ever accessible telescopic vision, as it were, of the various civilizations of the earth, although ever so remote or scattered. But, even then, the visitors, however great their multitude, could never be expected to comprise more than a small fraction of the thinking and inquisitive classes of society. The best substitute therefore which the case admits of plainly seems to be of the sort adopted and carried out by the Federal Government for the use and satisfaction of these United States; that is to say, a well appointed and sufficiently numerous commission to witness, examine and report upon the Exposition and the groups and classes of objects therein represented; and the Reports to be printed by the Government for general distribution. Besides the primary 'General Survey of the Exposition,' from the pen of Charles B. Seymour, chairman of the Committee, instructed for that purpose by the Department of State, and its preface by N. M. Beckwith, U. S. Commissioner General, and President of the Commission, the Reports are before us, so far as their publication has been completed. By far the most voluminous, various and extended of the number is that of President Barnard, the title of which is employed above as an introductory heading to these remarks. It is an octavo of 650 pages, filled with descriptions, illustrations and theoretic determinations, illustrated with numerous clearly executed cuts on the pages, and concluded by eight elaborate and finely wrought engravings. The finished artistic execution of this and of all the volumes or reports is obviously due, in no small measure, to the taste, good judgment and accuracy of Prof. W. P. Blake, who superintended the publication, as its editor. It sets off to advantage the intrinsic value and eminent adornments of the report,—both the matter and the author's style of rendering it. Next to the privilege of one's own presence amid the immense and diversified assemblage of objects in the Exposition, is the experienced satisfaction and advantage of finding one's self in presence of a large collection of the most select and suggestive of the number, brought into one view through the medium of luminous, graphic and illustrated descriptions. The author not confining himself to mere delineation, as he passes from object to object, takes pains to instruct us in their subsisting mutual connections and dependencies, and to explain in each the distinctive uses of parts, the modes of general operation, and the rationale of effects. Often indeed, if we will stay to go deeper, he puts at our disposal his well understood powers of analysis, dissipates the fallacies which becloud the mechanician's conceptions, and reconciles those paradoxes which, to the popular mind, often carry the semblance of an inevitable discord between those two

wedded and indissoluble partners, Theory and Practice. And we attend to these all the more earnestly that our author's opening chapter had impressed us, as at the vestibule and entrance of our survey, with the intimacy and imminence of 'The relation of invention to industrial progress.' That model chapter traces and exhibits with unwonted distinctness the dependence of art upon other art, and of art upon its own created auxiliaries: thus the steam engine first put within the workman's reach those operative and refined tools to which the steam engine itself owes its progressive improvement and existing completeness. In following out the like connections and dependencies we are also led to perceive, not indeed for the first time but with intensified vividness, how deeply art and invention project their influences into economic and social life, into trade and commerce, into civilizing effects abroad, into the habits of thinking and feeling at home, and even into politics and the nations's destiny. Thus, the cotton-gin expanded itself into a prime mover not only of all-pervading activities in the manufactory and on the ocean, but even of the vast combinations and issues themselves of war and peace. Here is no exaggeration; still we conceive, with our author, that not the individual inventor alone is to be recognized as the originating instrumentality of all this, except as one which the age itself had brought up into preparation for his invention, and in whom the invention sprang up because the age had created a demand for it.

The dependencies of industrial art may be spoken of in various senses,—*massively*, for instance, as resting upon force, its modifications and applications,—or *quantitatively*, as resting for the abundance and multiplication of its products, upon facile machinery, manipulation and skill,—or *inductively*, as resting upon knowledge and ingenuity for its origination and progress. A glance at the table of contents and headings of the chapters of the report, will suggest how considerably some such natural classification, whether or not so intended, has influenced our author in the selection of his subjects and in their arrangement. Of the eighteen chapters, five are occupied with the subject of *power* in its various mechanical relations; as, first, the prime movers, steam, air, water, electricity and their enginery; next, the transmission of power, then its accumulation, then its measurement and registration, and, lastly, its massive applications. The eight middle chapters are taken up mainly with the appliances, the methods and the instrumentalities of ingenuity, tact and sagacity, as used for the purpose of *production*, and acting through all the range and agencies of heat, cold, excitation, pressure and motion,—sometimes the production of improved material, and sometimes the production of improved

effects, or of articles and implements for ornament and use, in their variety, their finish, and their aptitudes, as well as the rapidity and multitude of their manufacture. The concluding four chapters are occupied with the 'exact sciences' considered in their mechanical and practical relations. We read with wonder of the success with which measurements are carried to an exactness well nigh rivalling, to all intents, the mathematical itself,—of rods ascertained to a millionth of an inch in length, and of balances that perform to a twenty-millionth part of their burden. We are delighted to trace anew the progress by which the human eye has become enabled, through the perfection of object-glasses enormous in dimension, on the one hand, or of minute sizes on the other, to penetrate into the universe outwardly, and into the bosom of nature inwardly. We are let into the surprising secret by which mechanism is made to render numerical computations with greater exactitude and with immeasurably greater promptness than the mental faculties of the computer himself could realize. We are instructed how to make sound itself a thing of visible undulations, and how to apply a measuring scale to their continuance. Not much, it is true, of the Exposition, as the author himself is careful to say, was absolutely new, as respects *elementary* inventions; and, therefore, not much of that quality and essence could have place in any faithful account of it. The report is simply, and admirably, a representation by just and varied selections, of the stage of progress which industrial art and invention had reached in the year 1867. Although necessarily partial it still embraces a collection ample for its purpose; that is to say, for giving a near birdseye view of the Exposition, and, like the walks and avenues of the Exposition itself, diversified by occasional fragments of history and relics of legendary lore. Taken together it forms a resort where the engineer may obtain reassurance, the mechanic experience, the inventor impulse guidance and correction, and the man of intellect or of letters choice entertainment. The report is printed as a public document, and has not been ordinarily obtainable otherwise than by and through members of the United States Senate, each of whom, as we are informed, had the distribution of some fifteen entire series, each corresponding to the one of which this report is a constituent.

The United States was not largely represented, as respects numbers, in its own section of the Exposition. The country was too much occupied with new and extraordinary domestic questions. Industry was unsettled in many respects. The subject had not attracted the earliest attention; and the field was very distant. Yet our national exhibit, although not extended in scale, was excelled in quality only by France

itself—and that in no very considerable degree—while the percentage of awards relative to the number of exhibitors was double the corresponding percentage for England and her colonies.

No extracts which our space would allow could do justice to the report, especially if not accompanied by the cuts or engravings; and if we were to instance and enlarge upon passages and descriptions that appear specially important, it would convey no conceptions to the reader comparable with what he will obtain by a reference to the work itself. We only add, in justice to the distinguished author, that, while he is thoroughly American in a due anxiety to set forward the claims of his countrymen, it is with an obvious impartiality toward all the competitors, and with a diligence whose regulating principle is truth and an endeavor for the benefit of mankind in general.

Art. XXII.—*On Norite or Labradorite Rock;* by T. Sterry Hunt, LL.D., F.R.S.

[Read before the American Association for the Advancement of Science, at Salem, August, 1869.]

The various rocks composed essentially of a triclinic or anorthic feldspar, with an admixture of hornblende, pyroxene, hypersthene or diallage, have by lithologists been designated by the names of diorite, dolerite, diabase, hypersthenite and gabbro, among others. The latter name has by many been regarded as synonymous with euphotide. I however pointed out many years since that the true euphotide is not a feldspathic rock, but consists of a mixture of diallage with saussurite, a white heavy silicate apparently identical with zoisite. By an admixture of labradorite or an allied feldspar, however, euphotide passes into the so-called gabbro, which I have defined as a diallagic diabase (this Journal, II, xxvii, 336), and which is closely related to norite. The name of hypersthene rock or hypersthenite (sometimes contracted into hyperite), was given by MacCulloch* to a rock consisting of labradorite, or a related feldspar, and hypersthene, found by him in the Western Islands of Scotland, and subsequently recognized by Emmons in the Adirondack Mountains of northern New York. By both of these observers it was regarded as an erupted rock. In 1851 I detected it among the Laurentide hills of Canada, where, as in New York, it extends over considerable areas. Farther examinations of this rock in place showed that though hypersthene, generally in very small proportion, is a frequent element, it is often

* MacCulloch, Geology of the Western Islands, i, 385–390.

replaced by a green granular pyroxene, and still more often both of these are wanting, so that we have a rock composed almost entirely of a triclinic feldspar, whose composition is generally near that of labradorite, but varies in different examples from that of andesine to near that of anorthite. To these rocks I provisionally applied the name of anorthosites, the pure feldspathic type being regarded as normal anorthosite, associated with which, however, were to be found hypersthenic and pyroxenic varieties. Red garnet, epidote, a black mica, and more rarely dichroite and quartz, are all occasionally found sparingly disseminated in these anorthosites of New York and Canada, which cannot be distinguished from those first observed by MacCulloch in the Isle of Skye, as I have convinced myself by an examination of the specimens there collected by him, and now preserved in the collections of the Geological Society of London. Titaniferous iron ore (menaccanite) also frequently occurs in grains and masses in these rocks, both in Skye, and in North America, where it sometimes forms beds or masses of considerable size. Details as to the chemical and mineralogical characters of these rocks will be found in the L. E. & D. Philos. Magazine for May, 1855, and also in the Geology of Canada, 1863, pages 588–590.

The subsequent investigations of Sir William Logan have shown that these anorthosites in Canada belong to a great series of stratified crystalline rocks which by the geological survey of Canada have been designated the Labrador or Upper Laurentian series, and which repose unconformably upon the older or true Laurentian gneiss and limestones. The area of the Labrador formation most examined lies in the counties of Argenteuil and Terrebonne, to the north and northwest of Montreal, and has a breadth of more than forty miles. It is however met with on the northeast shore of Lake Huron, according to Dr. Bigsby,* and at several points below Quebec, notably in the parish of Château-Richer, at Bay St. Paul, and around Lake St. John on the Saguenay, where it occupies a large area. Proceeding northeastward along the left bank of the St. Lawrence, Mr. Richardson has lately observed it at the mouth of Pentecost river, about 160 miles below the entrance to the Saguenay, and I have found it forming the shore of the Bay of Seven Islands forty miles farther down. This area is probably connected with the wide extent of this rock observed by Prof. Hind on the river Moisie. In all of these regions it appears to be surrounded and limited by the ordinary Laurentian gneiss. Bayfield, moreover, describes a rock with a base of labradorite as forming the coast for several miles near Mingan. Finally, it is widely spread on the coast of Labrador, where its characteristic mineral was first found, and from whence it takes its name.

* Geology of Canada, 1863, page 480.

Prof. A. S. Packard, Jr., has given us valuable information with regard to the occurrence of labradorite rocks at some points on the Labrador coast.* One of its localities is at Square Island, just north of Cape St. Michel, where the rock consists chiefly of crystalline labradorite smoky gray in color, translucent, and opalescent with greenish reflections. This feldspar often shows cleavage planes two inches broad, and is associated with a little vitreous quartz and with coarsely crystalline hypersthene, which appears in relief on the weathered surfaces. This labradorite rock, according to Prof. Packard, is surrounded by and probably rests upon Laurentian gneiss. At Domino Harbor he found domes or bosses of a similar labradorite resting upon strata which consist in great part of a slightly schistose quartzite, having for its base a granular vitreous quartz, and enclosing grains of black hornblende, more rarely hypersthene, black mica, and red garnet. Feldspar is generally wanting, but in some parts these quartzites become gneissic, and they were nowhere seen in uncomformable contact with the Laurentian gneiss of the vicinity. These quartzose strata Prof. Packard refers, with some doubt, to the Huronian system. The minerals which they contain are not however met with, so far as known, in the Huronian quartzites, and on the contrary, are very characteristic of the quartzites of the Laurentian system, which attain a great thickness in many parts of its distribution. The overlying domes of labradorite rock, which Prof. Packard was inclined to regard, in this case, as erupted through Huronian quartzites, are probably nothing more than outlying portions of the newer Labrador formation resting upon the Laurentian strata, as already observed by him at Square Island. Along the western coast of the island of Newfoundland Mr. Jukes observed at Indian Head and at York Harbor dark colored rocks composed of labradorite and hypersthene, and others of albite (?) and hypersthene, which may probably be found to belong to the Labrador series.

Rocks composed chiefly of labradorite or a related feldspar greatly predominate in the Labrador series, but these, at least in the area near Montreal, which is the one best known, are interstratified with beds of a kind of diabase in which dark green pyroxene prevails, with crystalline limestone similar in mineralogical characters to that of the Laurentian system, and more rarely with quartzites and thin beds of orthoclase gneiss. I have more than once insisted upon the rarity of free quartz and the general basic character of the rocks in this series, an observation with which I am credited in Dana's Manual of Geol-

* On the Glacial phenomena of Labrador and Maine. Mem. Bost. Acad. Nat. Hist., vol. I, part ii, pp. 214–217.

ogy (p. 139), where it seems to be applied to the whole of the rocks there classed as Azoic, including the Laurentian, Labradorian and Huronian systems. It is, in fact, remarkable that the silicated rocks of the latter two consist chiefly of labradorites, diorites and diabases; gneissic and granitic rocks being exceedingly rare among them, though quartzites abound in the Huronian. In the Laurentian system, on the contrary, though basic silicated rocks are not wanting, orthoclase gneisses, often granitoid in structure, and abounding in quartz, predominate.

The anorthosite rocks of the Labrador series present great variations in texture, being sometimes coarsely granitoid, and at other times finely granular. They not unfrequently assume the banded structure of gneiss, lines of pyroxene, hypersthene, garnet, titanic iron ore or mica marking the planes of stratification. Probably three-fourths of the anorthosites of this series in Canada, whether examined in place or in the boulders which abound in the St. Lawrence valley, consist of pure or nearly pure feldspar rocks, in which the proportion of foreign minerals will not exceed five hundredths. Hence we have come to designate them by the name of labradorite rock. The colors of this rock are very generally some shade of blue, from bluish-black or violet to bluish-gray, smoky gray or lavender, more rarely purplish passing into flesh red, greenish-blue, and occasionally greenish or bluish-white. The weathered surfaces of these labradorite rocks are opaque white. The anorthosites which occupy a considerable area in the Adirondack region, as described by Emmons in his report on the Geology of the Northern district of New York, and as seen by me in hand specimens, closely resemble the rocks of the Labrador series in Canada.

In all of these localities the coarse or granitoid varieties often hold large crystalline cleavable masses, generally polysynthetic macles, and frequently exhibiting the peculiar opalescence which belongs to labradorite. Although rocks composed of labradorite or similar feldspars, with hornblende or pyroxene, occur in various other geological formations, both as indigenous greenstones and as erupted masses, they never, so far as my observation in North America goes, exhibit the peculiar character just described; namely, that of a granular or granitoid rock composed of nearly pure labradorite or some closely related feldspar, frequently opalescent, and generally of a bluish color, often violet, smoky blue or lavender blue. This type of rock seems in North America to characterize the Labrador series.

It may here be remarked as an interesting fact bearing on the distribution of the Labrador series, that two large boulders of labradorite rock, one of the beautiful dark blue variety, are found on Marblehead Neck on the coast of Massachusetts. It

does not seem probable that these masses could have been derived from any of the far off localities already mentioned, and the fact that the gneiss of eastern Massachusetts is, as I have recently found, in part of Laurentian age, suggests that an outcrop of the Labrador series may exist in some locality not far removed. In this connection it may be added that I have lately found characteristic labradorite and hyperite rocks in southern New Brunswick, a few miles east of St. John, occupying a position between the Laurentian and the Huronian or Cambrian rocks, which there make their appearance, accompanied by Lower Silurian strata, to the south of the great Carboniferous basin of the region. This interesting locality was recently pointed out to me by Mr. G. F. Matthew of St. John, to whom we are indebted for a great part of our knowledge of the geology of southern New Brunswick. Chester and Bucks counties in Pennsylvania, and the Wichita Mountains in Arkansas, are cited in Dana's Mineralogy as localities of labradorite, but as I have never examined specimens from these places, I am unable to say whether they resemble the characteristic anorthosites of the Labrador series already described.

The name of norite, in allusion to Norway, was given by Esmark to a rock composed chiefly of labradorite, which is found in several localities in that country.* I had already noticed the close resemblance between two specimens of norite obtained from Krantz of Berlin, and the labradorite rocks of North America just noticed, when in 1867 I had the opportunity of examining at the Universal Exhibition at Paris, a collection of Norwegian rocks selected for ornamental purposes, exhibited by the Royal University of Christiania. Prominent among these was a series of the norites, which could not be distinguished from the labradorite rocks of the Upper Laurentian or Labrador series of this continent. In a printed note accompanying this collection from the University it is said that the numerous varieties of rocks consisting of labradorite with hypersthene, diallage and bronzite, have, in the geological map of Southern Norway, published at Christiania in 1866, been designated by the common name of gabbro. This note at the same time suggests that "the name of norite should be preserved for certain varieties of gabbro rich in labradorite, which varieties may in great part with justice be called labradorite rock, since labrador feldspar is their predominent element." With this excellent suggestion I heartily concur, remarking, however that the name of gabbro, as an ill-defined synonym for certain anorthosite rocks, including in part diorite, diabase, hyperite, and even confounded with the non-feldspathic rock euphotide, may very well be dispensed with in lithology.

* See farther Zirkel, Petrographie, II, 131.

By referring to the geological map just mentioned, it will be seen that these so-called gabbros occupy considerable areas in the Laurentian gneiss region of Norway. By the authors of the maps, Messrs. Kjerulf and Dahl, these gabbros are regarded as eruptive, though they are described at the same time as often assuming the character of stratified rocks. It should however be noticed that these geologists go so far as to regard the whole of the granitic gneiss of the region as unstratified and of plutonic origin.

The specimens of these norites exhibited in Paris were in blocks polished on one side, and as was observed in the note accompanying them, presented a curious resemblance to certain varieties of marble. It is worthy of remark that Emmons in his report on the Geology of the Northern District of New York, suggested the application of the labradorite rocks of Essex county as a substitute for marble (pages 29, 418). An ornamental vase of the same rock turned in a lathe with the aid of a black diamond, has been in the Museum of the Geological Survey of Canada since 1856.

Of the collection of norites from Norway the specimens from Sogndal and Egersund presented fine varieties of grayish or brownish violet tints, while a dark violet norite came from Krageroë and also from the islands of Langoë and Gomoë, and a white granular variety from the gulf of Laerdal in the diocese of Bergen.

It is only in rare cases that the cleavable feldspar of these norites exhibits the peculiar opalescence which distinguishes the finer labradorite found in some parts of the coast of Labrador. Opalescent varieties of this feldspar are however occasionally met with in the area near to Montreal, and in northern New York. In the Paris Exhibition of 1867 there were exhibited from Russia, large polished tables of a beautiful violet colored granitoid norite, portions of which exhibited a fine opalescence. This rock, I was informed, comes from a mountain mass in the Government of Kiew, but of its geognostical relations I am ignorant.

These peculiar labradorite rocks, presenting a great similarity in mineralogical and lithological character, have now been observed in Essex county, New York, and through Canada at intervals from the shore of Lake Huron to the coast of Labrador. They are again met with in southern New Brunswick, in the Isle of Skye, in Norway, and in southwestern Russia, and in nearly all of these localities are known to occur in contact with and apparently reposing like a newer formation upon the ancient Laurentian gneiss. Giekie in his memoir on the geology of a part of Skye,* appears to include the norites or

* Quar. Jour. Geol. Soc., xiv., p. 1.

hypersthenites of that island with certain syenites and greenstones, which he describes as not intrusive, though eruptive after the manner of granites (loc. cit., p. 11–14). The hypersthenites are represented in his map as occurring to the west of Loch Slapin. Specimens in my possession from Loch Scavig, a little further west, and others in MacCulloch's collection from that vicinity, are however identical with the North American norites, whose stratified character is undoubted. I called attention to these resemblances in the Dublin Quarterly Journal for July, 1863,* and Haughton, who in 1864 visited Loch Scavig, has since described and analyzed the rock of that locality, which consists of labradorite, often coarse grained, with pyroxene and menaccanite, and is evidently, according to him, a bedded metamorphic rock (Dublin Quar. Jour., 1865, p. 94). He, it may be remarked, designates it as a syenite, a term which most lithologists apply to rocks whose feldspar is orthoclase.

I desire to call the attention of both American and European lithologists to this remarkable class of rocks, of which the norites may be regarded as the normal and typical form, in the hope that they may be induced to examine still farther into the question of the age and geognostical relations of these rocks in various regions, and to determine whether the mineralogical and lithological character which I have pointed out are geological constants.

ART. XXIII.—*On the cause of the color of the Water of Lake Leman, Geneva;* by AUG. A. HAYES, M.D., Assayer to State of Massachusetts.

THE traveler, who enters Switzerland at Geneva, always has his attention arrested by the beautiful azure color which the water of Lake Leman presents, especially when as one looks into its depths, the color is in contrast with the white reflection of clothing below the surface, at points where the laundresses pursue their avocations.

* I, at the same time, called attention to the Laurentian aspect of the crystalline limestones of Iona, which I found in MacCulloch's collection. Limestones not unlike these occur in Skye, intermixed with serpentine, and are, according to Mr. Giekie, associated with the protruded syenites of that region. With all deference to the authority of that eminent geologist, I cannot help suggesting that a re-examination of the district would show that the highly-inclined metamorphic crystalline limestones, holding serpentine, and associated with syenitic rocks, belong to an older system (probably Laurentian), and are thus distinct from the nearly horizontal fossiliferous liassic limestones near by, which are only locally altered by intrusive rocks. American geologists will at once recall the mis-conception which led most of our best observers during many years to look upon the old Laurentian limestones of New York and New Jersey as altered portions of the overlying paleozoic strata.

Many will remember the expression of Sir H. Davy, that "this color is doubtless due to some compound of iodine," and not only chemists, but geologists have speculated on the cause of this coloration, quite frequently with opposite opinions.

Both in composition and general characters, this water belongs to a class I have been accustomed to describe as "White waters," or colorless waters, which, chemically considered, always hold a salt called crenate of lime in solution, and mark in their color the existence of lime salts, in their course as rivers, or in contact with them, as reposing in true lakes. At many points in Switzerland these white waters are found, and indicate clearly the occurrence of calcareous matter, more extensively diffused than surface observations of the rocks would allow in some districts.

Among the Tyrolese Alps, too, lakes and streams present the same cerulean hue, which gives character and beauty to the water of Lake Leman, and I have seen even small collections of water there apparently as highly colored as the more noted lakes. "White waters," when clear, always present this hue, and when turbid, a green hue, due to reflection from particles of solid matter. In the summer of 1858, I commenced a careful analysis of the water of Lake Leman at Geneva, and had found a general accordance with the published statements of composition; but the special search for coloring matter, was prevented by the inopportune recurrence of rain, and subsequent disappointment at a point on the Rhone above the lake.

Since that time this water has been analyzed by distinguished chemists, such as Will, Dafour, and Blanche, whose results only show the presence of more salts in number in the solid matter, and the slight variations in proportions which we should expect would occur, under variations of volume and temperature, in the water at different seasons.

These analyses, I learned, were made in the usual way of evaporating the water for the solid products, and driving off and collecting the gases, a method which enables us to answer many questions, but does not permit the nicer determinations of organic bodies, if present, in a natural or an altered state. Analysis so conducted would not allow us to answer the question in relation to the cause of color, unless it could be traced to some known or unknown fixed compound. Nor would such an analysis determine the weight accurately of the whole amount of matter, naturally dissolved in the water, as it is easy to prove that a loss of matter takes place during the evaporation, even if conducted at a moderate temperature—the great point of state of hydration of the organic salts, and to some extent that of the saline matter, is ignored entirely when we proceed in this way to determine the quantity and kind of constituents.

Nearly all waters contain living organisms, and their germs, these matters, in a decomposing state, organic acids, either with or without bases, in the form of salts, most easily changed by heat or even by concentration. These substances are very important constituents, in connection with the uses of the water, and I could offer many illustrations of damage in manufacturing and unfitness for consumption, traceable directly to the presence of such bodies in waters otherwise desirable, and proper for extended consumption.

The mode adopted in my examination of the water of Lake Leman is that which I have usefully applied in a large number of cases, and with modifications, it is applicable to all waters, in connection with other well known steps of analysis.

A large volume of the water of Lake Leman was mixed with a small portion of a diluted solution of sub-acetate of lead quickly and uniformly diffused. Another portion was treated in the same way, with a water solution of pure soap—both precipitates slowly formed, were collected in a moist state, subsequently examined by the microscope, and were found to contain only the ordinary constituents of white waters, when so treated.

The negative results of these trials in this connection, were sufficient to prove the absence of all coloring or colored bodies in this water—the strong attraction of the basic salt of lead for all coloring matter is well known—its power of removing colored infusoria is equally great. The calcareous soap product formed from the test removes all suspended matter, and permits us to detect organic forms with ease and certainty, after the fatty matters are dissolved on a glass slide.

It is obvious that in cases of complete analysis of waters, these precipitates should be subsequently chemically treated, and their state of hydration found, and engaged compounds separated and weighed.

Chemical analysis, thus conducted, having thrown no light on the cause of color in this water, has proved the absence of coloring substances, and placed it in the list of those waters, which do not exhibit the color seen in this lake; we are, therefore, led to ascribe the origin of its peculiar tint to natural influences, namely, the reflection and refraction of an azure sky in a colorless water.

The sky coloration of this part of Switzerland early engaged the observation of Saussure, who even experimented on its depth of color, while retaining its blue tint. All the conditions favoring almost constant blueness of sky, are present in this, and other parts of Switzerland in a marked degree, and I believe that extended observation will always connect the blue tint of white water with the deep azure hue of the clear sky above it.

By carefully watching the influence of the light from the sky on the water of this lake, I observed here as elsewhere that depth of color and tint in the water were modified greatly, or even lost under varied light from the sky. As the sun declined the azure tint was replaced by a grayish hue, or a light gray color was the closing hue of a series of shades of color. If the clear sky became flecked with small cloud surfaces, the water responded in unequal coloration, as if the water mirrored the sky, under this condition of beauty.

In other countries, there are bodies of colorless water which do not exhibit the coloration, commonly seen in Lake Leman water. Such localities are not favored with clear blue skies through atmospheric constitution, and bluish greenness of tint is the nearest approach to azure hue, which the sky permits, excepting perhaps at rare moments.

The negative results of chemical analysis, and the sufficiency of the effect of reflected and refracted light of the sky, which is over the water of Lake Leman, led me to the conclusion that the cause of color is found in the peculiar hue of the sky, so transmitted to the eye by a colorless water.

Boston, Mass., December 10th, 1869.

ART. XXIV.—*Contributions to Chemistry from the Laboratory of the Lawrence Scientific School.* No. IX.—*On the Potassio-Cobaltic Nitrite known as Fischer's Salt, and some analogous and related compounds;* by SAMUEL P. SADTLER.

THE composition of the double nitrite of cobalt and potash, known by the different names of "Fischer's Salt" and "Cobalt-yellow," has long been an open question. The following is a brief statement of the views advanced on the subject. Fischer* the discoverer of the salt made no analyses of it. St. Evre† who rediscovered it gave as a formula for it $K_2\Theta N_2\Theta_4 + Co\Theta N_2\Theta_4$, but does not give the analytical data. Stromeyer‡ subsequently showed the incorrectness of this view and wrote the formula $Co_2\Theta_3$, $2N_2\Theta_3 + 3(K_2\Theta N_2\Theta_3) + 2H_2\Theta$. This formula is peculiar in making the atom $Co_2\Theta_3$ combine with 2 atoms of $N_2\Theta_3$. We shall discuss the formula and results farther on. Erdmann§ first pointed out a distinction between the salt formed in neutral solutions and the salt formed in acid solutions, which latter he considers as a normal salt. He gives both

$$2Co\Theta,\ 3N_2\Theta_3 + 3(K_2\Theta N_2\Theta_3) + 3N_2\Theta,\ \text{and}\ Co_2\Theta_3 3N_2\Theta_3 + 3(K_2\Theta N_2\Theta_3) + 3H_2\Theta$$

* Pogg. Ann., lxxii, 477 and lxxiv, 124.
† Jr. pr. Ch., 54, 84 and 58, 185.
‡ Ann. Ch. u. Ph., xcvi, 218.
§ Jr. pr. Ch., lxxiii, 598.

or as we shall write it $Co_2 6N\Theta_2 + 6(KN\Theta_2) + 3H_2\Theta$. Braun* the last writer on the subject, passes most of the preceding work in review. He takes up Stromeyer's results, and rejecting his views as to the composition of the salt analysed by him, figures for it a number of ingenious but somewhat complicated formulas. He considers that neither the "neutral salt" nor the "acid salt" of Erdmann can be regarded as anything but mixtures or "poly combinations," and for the first of them considered as such he gives a still more ingenious and complicated formula. We quote it as reduced to its empirical form by Blomstrand:† $Co_{62}K_{59}N_{112}H_{20}O_{454}$.‡ Braun's own results are expressed first by a formula containing both $Co_2\Theta_3$ and $Co\Theta$, then by one containing $Co_2\Theta_3$, $Co\Theta$, $N_2\Theta_3$ and $N_2\Theta_5$ and finally by the following:

$$3(Co_2\Theta_3, 3N_2\Theta_3 + 4K_2\Theta, 4N_2\Theta_3 + 2H_2\Theta) + 2(Co_2\Theta_3, H_2\Theta, 2N_2\Theta_3 + K_2\Theta, N_2\Theta_3 + 3H_2\Theta).$$

The experiments made to settle its composition and the results obtained are as follows: St. Evre ignited the salt in a stream of nitrogen. Nitric oxyd was given off and the residue was a black oxyd, which on contact with HCl gave Cl and with $C_2H_2\Theta_4$ gave CO_2. This I cannot regard as conclusive, as mere ignition per se will not break up the $KN\Theta_2$, so that the residue was not pure $Co_2\Theta_3$; moreover the $N_2\Theta_3$ in breaking up may have given an atom of Θ to form the $Co_2\Theta_3$. Stromeyer found that $NaH\Theta$ and $BaH_2\Theta_2$ decompose it on gentle warming, even with exclusion of air, separating the brown hydrated $Co_2\Theta_3$ which dissolves in $C_2H_4\Theta_2$ with a brown, and in $C_2H_2\Theta_4$ with a green color. This observation is of undoubted value. He says also that on mixing the neutral solutions, the precipitate is slow in forming, and forms by an absorption of Θ, as is shown by dipping the connecting tube under a cylinder of air or oxygen. Erdmann confines himself to an examination of this last observation of Stromeyer's and finds that the "neutral salt" can be formed in an atmosphere of pure CO_2, and that therefore there can be no absorption of Θ in the case. Braun finds that $KH\Theta$ acts very little upon the salt, merely changing its color from yellow to a dirty yellowish-green. $NaH\Theta$, $BaH_2\Theta_2$, $CaH_2\Theta_2$ separate at a boiling heat the brownish-black hydrated $Co_2\Theta_3$. This is confirmatory of Stromeyer's observation. Carbonate of silver heated with water and Fischer's salt gave with separation of the hydrated $Co_2\Theta_3$, crystals of what from Braun's description were probably $AgN\Theta_2$. KCy did not decompose it.

* Zeitsch. Anal. Ch., vii, 313.

† Chemie der Jetztzeit, p. 414.

‡ Should be O 508.

My own experiments directed toward the solution of the question of $\mathfrak{C}o\Theta$ or $\mathfrak{C}o_2\Theta_3$ were as follows: I found Erdmann's observations as to the formation of the "neutral salt" in an atmosphere of $\mathfrak{C}\Theta_2$ correct. I added by means of a funnel tube a solution of $KN\Theta_2$ boiled to expel the air, to a boiled solution of $\mathfrak{C}o\,Cl_2$, placed at the bottom of a partially closed vessel, into which a strong stream of $\mathfrak{C}\Theta_2$ had been passing for some time. The salt began nevertheless to form slowly. Wishing to sift the matter more thoroughly, I made a series of experiments in eudiometer tubes over mercury. Into a eudiometer tube filled with mercury and perfectly free from air, I threw up a boiled solution of $\mathfrak{C}oCl_2$ and then one of $KN\Theta_2$. The salt began to form soon at the juncture of the two liquids and then deposited steadily though slowly. After a number of hours not the slightest bubble of air was to be seen. The absence of all chance of oxydation here, either from air or excess of nitrous acid, shows conclusively the protoxyd nature of this "neutral salt." The "acid salt" was formed in the same manner—first a boiled solution of $\mathfrak{C}oCl_2$, then acetic acid, and then a boiled $KN\Theta_2$ solution. A rapid evolution of gas ensues and the salt forms and falls in a layer on the top of the mercurial column. In another instance a small crystal of $\mathfrak{C}oCl_2$ was sent up and then acetic acid and then $KN\Theta_2$. The formation of the salt was almost instantaneous and the evolution of gas exceedingly rapid. Before drawing any conclusions from this, however, the action of acetic acid on $KN\Theta_2$, out of access of air, was to be studied. Gmelin* states that, when treated with acid out of access of air, nitric oxyd is evolved while the liquid takes up $N\Theta_2$ and $N_2\Theta_5$. This evolution was found to take place readily over the mercury and the gas answered to the test of ferrous sulphate and was colored red on admission of air, like the gas evolved in the formation of the salt. The question now is whether the liberated Θ is taken up in the formation of the salt to oxydize the $\mathfrak{C}o\Theta$, to convert the excess of nitrite into nitrate. The question cannot be definitely settled, until we have some delicate test for a small quantity of nitrate in the presence of a large quantity of nitrite. But there is one thing which I regard as significant. Erdmann made one of his preparations of the "acid salt," by filtering the mixture of neutral solutions into pure acetic acid. Now the greater the excess of acid, the quicker would be the conversion of nitrite into nitrate, and we should look for a very small amount of the double nitrite salt. Yet it formed as readily, and analysis proved it to possess the same constitution as the other preparations. The inference from this is, that the

* Cav. Soc. ed. vol. ii, p. 382.

sesquioxyd-forming power of the Co is sufficient to enable it to take liberated oxygen.

Recourse was now had to analysis as a means of determining the question. Six distinct preparations of the salt in all were made and analyzed. In preparing the salt, the distinction made by Erdmann in regard to the formation of different compounds in neutral and acid solutions, was recognized and the salt was invariably formed in a solution, strongly acidified by acetic acid in the beginning, and kept so until the end by the addition of acid, if necessary. The salt of cobalt used was the chlorid, and, in all but the first two preparations, the solution was boiled to expel air and made acid. A strong solution of $KN\Theta_2$ was then added and the mixture was left to stand: 6 to 12 hours generally proved sufficient, and it was then filtered and washed, according to Erdmann's direction, with a solution of potassic acetate of about 10 per cent which was displaced by 80 per cent alcohol. The salt was then dried, first over the water-bath and then in a water-oven exactly at 100°. I saw no evidence of a decomposition at this temperature alluded to by Erdmann.

The results of full analyses of these six preparations warrant me I think in presenting the following conclusions:—

1st. That Fischer's salt is a *Tri-potassic-Cobaltic-Nitrite*, its essential formula being $Co_2\Theta_3, 3N_2\Theta_3 + 3(K_2\Theta, N_2\Theta_3) + Aq$, or $Co_2 6N\Theta_2 + 6(KN\Theta_2) + Aq$.

2nd. That it can be formed with $4H_2\Theta$, $3H_2\Theta$, $2H_2\Theta$, $H_2\Theta$, or anhydrous, according to the degree of concentration of the solutions used, passing in color from a light yellow to a dark greenish-yellow.

3rd. That in consequence of such dependence, we can, in in most preparations, fix no absolute point, but are liable to have a mixture of salts of different degrees of hydration.

The analytical methods used in the analyses of the salt were the following:—

The Co was determined first together with the K, as a double sulphate having the invariable constitution $Co_2K_2 5S\Theta_4$. This sulphate has a distinct fusing-point, and affords an accurate means of determination. It will be discussed farther on. This is then dissolved, the solution made ammoniacal and brought to boiling, when the Co is thrown down as CoS. This is roasted and, after treatment with aqua regia and sulphuric acid, is weighed as neutral $CoS\Theta_4$. Or the Co was thrown down from the solution of the double sulphates as peroxyd by acetate of soda and chlorine, and then reduced by hydrogen to the metallic state.

The potash is then determined by difference.

The nitrogen was determined, either together with the $H_2\Theta$ by Gibbs's modification of Bunsen's method, which will be again alluded to, or directly by volume with the Sprengel-pump.

The $H_2\Theta$ either as above, or by combustion with Cu in a stream of $C\Theta_2$.

The analytical data and results are appended.

Preparation No. 1.

·2011 gr. salt gave ·1732 gr. $Co_2K_6S\Theta_4$=44·75 p. c. $Co\Theta+K_2\Theta$
gave also ·0656 gr. $CoS\Theta_4$=15·78 p. c. $Co\Theta$=17·47 p. c. $Co_2\Theta_3$.

·1626 gr. salt gave ·1403 gr. $Co_2K_6S\Theta_4$=44·83 p. c. $Co\Theta+K_2\Theta$
gave also ·0529 gr. $CoS\Theta_4$=15·74 p. c. $Co\Theta$=17·42 p. c. $Co_2\Theta_3$.

·5147 gr. salt gave 112·7 cc. nitrogen at 15·25° and 483·2 mm. pres.
=16·56 p. c. N=44·95 p. c. $N_2\Theta_3$.

·9410 gr. salt gave 167·6 cc. nitrogen at 15·25 and 601·6 mm. pres.
=16·76 p. c. N=45·48 p. c. $N_2\Theta_3$.

1·1131 gr. salt gave ·0793 gr. $H_2\Theta$=7·00 p. c. $H_2\Theta$.

1·3418 " " ·0937 " " 6·98 " "

Preparation No. 2.

·1082 gr. salt gave ·0955 gr. $Co_2K_6S\Theta_4$=45·86 p. c. $Co\Theta+K_2\Theta$
gave also ·0408 gr. $CoS\Theta_4$=16·16 p. c. $Co\Theta$=17·88 p. c. $Co_2\Theta_3$.

·1222 gr. salt gave ·1074 gr. $Co_2K_6S\Theta_4$=45·66 p. c. $Co\Theta+K_2\Theta$
gave also ·0455 gr. $CoS\Theta_4$=15·96 p. c. $Co\Theta$=17·66 p. c. $Co_2\Theta_3$.

·4192 gr. salt gave 102·83 cc. nitrogen at 18·25° and 462·6 mm. pres.=17·57 p. c. N.=47·70 p. c. $N_2\Theta_3$.

·4376 gr. salt gave

·6328 " " ·0346 gr. $H_2\Theta$=5·46 p. c. $H_2\Theta$.

·5494 " " ·0296 gr. $H_2\Theta$=5·39 p. c. $H_2\Theta$.

Preparation No. 3.

·6215 gr. salt gave ·5682 gr. $Co_2K_6S\Theta_4$=47·50 p. c. $Co\Theta+K_2\Theta$
gave also ·0797 gr. Co=12·82 p. c. $Co\Theta$=18·04 p. c. $Co_2\Theta_3$.

·5838 gr. salt gave ·5349 gr. $Co_2K_6S\Theta_4$=47·60 p. c. $Co\Theta+K_2\Theta$
gave also ·0740 gr. Co=12·68 p. c. $Co\Theta$=17·83 p. c. $Co_2\Theta_3$.

·4451 gr. salt gave ·4088 gr. $Co_2K_6S\Theta_4$=47·71 p. c. $Co\Theta+K_2\Theta$
gave also ·0574 gr. Co=12·89 p. c. $Co\Theta$=18·14 p. c. $Co_2\Theta_3$.

·5796 gr. salt gave ·5329 gr. $Co_2K_6S\Theta_4$=47·77 p. c. $Co\Theta+K_2\Theta$
gave also ·0735 gr. Co=12·68 p. c. $Co\Theta$=17·83 p. c. $Co_2\Theta_3$.

With 1·6634 gr. salt, combustion-tube lost ·3616 gr., of which $CaCl_2$ tube took up ·0710 gr.=4·27 p. c. $H_2\Theta$ leaving ·2906 gr.=17·47 p. c. N.=47·42 p. c. $N_2\Theta_3$.

With 1·5123 gr. salt, combustion-tube lost ·3302 gr., of which $CaCl_2$ tube took up ·0610 gr.=4·03 p. c. $H_2\Theta$ leaving ·2692 gr.=17·80 p. c. N.=48·32 p. c. $N_2\Theta_3$.

Preparation No. 4.

6677 gr. salt gave ·6073 gr. $Co_2K_6SO_4$=47·26 p. c. $CoO+K_2O$ gave also ·2258 gr. $CoSO_4$=16·36 p. c. CoO=18·11 p. c. Co_2O_3.

·3590 gr. salt gave ·3264 gr. $Co_2K_6SO_4$=47·24 p. c. $CoO+K_2O$ gave also ·1226 gr. $CoSO_4$=16·52 p. c. CoO=18·29 p. c. Co_2O_3.

With 1·1138 gr. salt, combustion-tube lost ·2461 gr., of which $CaCl_2$ tube took up ·0439=3·94 p. c. H_2O leaving ·2022 gr. =18·15 p. c. N.=49·27 p. c. N_2O_3.

With 1·2494 gr. salt, combustion-tube lost ·2674 gr., of which $CaCl_2$ tube took up ·0407=3·26 p. c. H_2O, leaving ·2267 gr. =18·14 p. c. N.=49·25 p. c. N_2O_3.

With 1·1587 gr. salt, combustion-tube lost ·2533 gr., of which $CaCl_2$ tube took up ·0432=3·73 p. c. H_2O leaving ·2101 gr. =18·13 p. c. N.=49·20 p. c. N_2O_3.

Preparation No. 5.

·2895 gr. salt gave ·2633 gr. $Co_2K_6SO_4$=47·26 p. c. $CoO+K_2O$ gave also ·0382 Co=13·20 p. c. Co=18·56 p. c. Co_2O3.

·3993 gr. salt gave ·3644 gr. $Co_2K_6SO_4$=47·42 p. c. $CoO+K_2O$ gave also ·0531 Co=13·30 p. c. Co=18·70 p. c. Co_2O_3.

·5747 gr. salt gave ·5243 gr. $Co_2K_6SO_4$=47·40 p. c. $CoO+K_2O$ gave also ·0769 gr. Co=13·38 p. c. Co=18·82 p. c. Co_2O_3.

·5959 gr. salt gave ·5443 gr. $Co_2K_6SO_4$=47·46 p. c. $CoO+K_2O$ gave also ·0768 gr. Co=12·89 p. c. Co=18·14 p. c. Co_2O_3.

With 1·2557 gr. salt, combustion-tube lost ·2758 gr., of which $CaCl_2$ tube took up ·0459=3·66 p. c. H_2O leaving ·2299 gr. =18·31 p. c. N.=49·69 p. c. N_2O_3.

With 1·1464 gr. salt, combustion-tube lost ·2556 gr., of which $CaCl_2$ tube took up ·0479=4·18 p. c. H_2O leaving ·2077 gr. =18·12 p. c. N.=49·18 p. c. N_2O_3.

Preparation No. 6.

·8154 gr. salt gave ·7644 gr. $Co_2K_6SO_4$=48·71 p. c. $CoO+K_2O$ gave also ·2823 gr. $CoSO_4$=16·75 p. c. CoO=18·54 p. c. Co_2O_3.

·5453 gr. salt gave ·5110 gr. $Co_2K_6SO_4$=48·69 p. c. $CoO+K_2O$ gave also ·1885 gr. $CoSO_4$=16·73 p. c. CoO=18·51 p. c. Co_2O_3.

·6805 gr. salt gave ·6373 gr. $Co_2K_6SO_4$=48·66 p. c. $CoO+K_2O$ gave also ·2358 gr. $CoSO_4$=16·77 p. c. CoO=18·55 p. c. Co_2O_3.

·3712 gr. salt gave ·3480 gr. $Co_2K_6SO_4$=48·71 p. c. $CoO+K_2O$ gave also ·1297 gr. $CoSO_4$=16·90 p. c. CoO=18·71 p. c. Co_2O_3.

With 1·5460 gr. salt, combustion-tube lost ·3033 gr., of which $CaCl_2$ tube took up ·0116=0·75 p. c. H_2O leaving ·2917 gr. =18·87 p. c. N=51·21 p. c. N_2O_3.

Prep. No. 1.

$Co_2 6NO_2 + 6(KNO_2) + 4H_2O$.

	Theor. p. cts.	Found p. cts.
Co_2O_3	17·00	17·45
K_2O	28·94	29·00
N_2O_3	46·69	45·21
H_2O	7·37	6·99

Prep. No. 2.

$Co_2 6NO_2 + 6(KNO_2) + 3H_2O$.

Theor. p. cts.	Found p. cts.
17·32	17·77
29·48	29·70
47·57	47·22
5·63	5·43

Prep. No. 3.

$Co_2 6NO_2 + 6(KNO_2) + 2H_2O$.

	Theor. p. cts.	Found p. cts.
Co_2O_3	17·65	17·96
K_2O	30·04	31·41*
N_2O_3	48·48	47·87
H_2O	3·83	4·15

Prep. No. 4 *and* 5.

$Co_2 6NO_2 + 6(KNO_2) + 3H_2O$.

Theor. p. cts.	Found p. cts.	
17·99	18·20	18·55
30·63	30·81	30·61
49·43	49·24	49·43
1·95	3·64†	3·92†

Prep. No. 6.

$Co_2 6NO_2 + 6(KNO_2)$.

	Theor. p. cts.	Found p. cts.
Co_2O_3	18·35	18·58
K_2O	31·24	31·90
N_2O_3	50·41	51·21
H_2O	0·	0·75

It will be seen that, while the general coincidence is well sustained, there are several decided deviations. We can only call attention to certain facts in explanation 1st. We probably have in some of these preparations, mixtures of the salts of different degrees of hydration. 2nd. The salt cannot be purified by re-crystallization. 3rd. The acetate of potash with which the salt is first washed is, as Rose‡ remarks, only removed with difficulty by the alcohol.

Having formed from these analytical results our conclusions, let us see if we can find any confirmation of them from other sources. Lang§ states that although the corresponding soda and ammonia salts were probably formed, yet they could not be obtained on account of their solubility. By using a strong $NaNO_2$ solution,‖ I succeeded in obtaining the new soda com-

* Acetate of potash probably not all washed out by alcohol.

† Unnaccountably high.

‡ Anal. Ch. sechste auflage, Zweiter Band, p. 128.

§ Jr. pr. Ch., lxxxvii, 303.

‖ The KNO_2 and $NaNO_2$ solutions used in this work were prepared as follows: 1 part of nitre and 2 parts of lead were fused together after Stromeyer's well-known method. After the complete oxydation of the lead, the residue was boiled several times with water. The solution was then filtered to remove the undissolved litharge. Into the filtrate which contained more or less free alkali, the red gas evolved from nitric acid and sawdust was passed until a neutral reaction was obtained This red gas, however, does not consist of the oxyds of nitrogen alone; it also contains some carbonic acid. This throws down as carbonate of lead, the litharge which

pounds, which I am about to describe. To a solution of $CoCl_2$, which had been boiled and then acidified with acetic acid I added an excess of $NaN\Theta_2$ solution. The mixture instantly became of a dark color and a yellowish-brown salt began to form, with brisk evolution of nitric oxyd. After some hours, when the evolution of gas was progressing but slowly, I added some more of the $NaN\Theta_2$ solution, testing also to assure myself that the solution was acid, and in a little while the solution began to assume a yellowish color, and I found a clear yellow salt depositing. This led to the conjecture that there were two distinct soda salts. I accordingly sought to obtain them distinct for analysis. This I found to be difficult. The brown salt I readily got almost pure, but succeeded only partially in obtaining the yellow one distinct. The brown salt continues to form, to a greater or less extent, even after the formation of the yellow one has begun. The preparations were all washed with acetate of soda, which was displaced with alcohol. From analyses of them, and from other and subsequent results, I am led to consider them as salts analogous to Fischer's salt and differing from each other in the number of atoms of $NaN\Theta_2$ in combination with the $Co_2 6N\Theta_2$. The brown salt I would call a *di-sodio-cobaltic-nitrite*, and the yellow one a *tri-sodio-cobaltic-nitrite*, giving them respectively the formulas:

$Co_2 6N\Theta_2 + 4(NaN\Theta_2) + H_2\Theta$. And $Co_2 6N\Theta_2 + 6(NaN\Theta_2) + H_2\Theta$

The following are the analytical results:

Brown Salt. 1st Preparation.

·5400 gr. salt gave ·4676 gr. $Co_2Na_4 4S\Theta_4$ = 39·94 p. c. $CoO + Na_2\Theta$
also gave ·2374 gr. $CoS\Theta_4$ = 21·27 p. c. CoO = 23·54 p. c. $Co_2\Theta_3$.

·5866 gr. salt gave ·5041 gr. $Co_2Na_4 4S\Theta_4$ = 39·64 p. c. $CoO + Na_2\Theta$
also gave ·2615 gr. $CoS\Theta_4$ = 21·57 p. c. CoO = 23·87 p. c. $Co_2\Theta_3$.

Brown Salt. 2nd Preparation.

·5602 gr. salt gave ·4805 gr. $Co_2Na_4 4S\Theta_4$ = 39·57 p. c. $CoO + Na_2\Theta$
also gave ·2425 gr. $CoS\Theta_4$ = 20·95 p. c. CoO = 23·18 p. c. $Co_2\Theta_3$.

·4671 gr. salt gave ·4027 gr. $Co_2Na_4 4S\Theta_4$ = 39·77 p. c. $CoO + Na_2\Theta$
also gave ·2026 gr. $CoS\Theta_4$ = 20·99 p. c. CoO = 23·23 p. c. $Co_2\Theta_3$.

With 1·7054 gr. salt, combustion-tube lost ·4476 gr., of which $CaCl_2$ tube took up ·1156 gr. = 6·78 p. c. $H_2\Theta$ leaving ·2920 gr. = 17·12 p. c. N. = 46·47 p. c. $N_2\Theta_3$.

had gone into solution. It is now filtered and the filtrate evaporated to an oily consistency, when the saltpetre in it will almost all crystallize out. We filter it again and if we wish it still purer we can give it the treatment with alcohol described by Hampe (Ann. Ch. u. Ph., 125, 335). This frees it completely from saltpetre and concentrates it.

With 1·8558 gr. salt, combustion-tube lost ·4476 gr., of which $CaCl_2$ tube took up ·1216=6·55 p. c. H_2O leaving ·3260 gr. =17·56 p. c. N.=47·67 p. c. N_2O_3.

Yellow Salt. 1st Preparation.

·6342 gr. salt gave ·5448 gr. $Co_2Na_65SO_4$=39·22 p. c. $CoO+Na_2O$
the Co determination was lost.

·5805 gr. salt gave ·4994 gr. $Co_2Na_65SO_4$=39·28 p. c. $CoO+Na_2O$
also gave ·2431 gr. $CoSO_4$=18·55 p. c. CoO=20·53 p. c. Co_2O_3.

Yellow Salt. 2nd Preparation.

·4197 gr. salt gave ·3700 gr. $Co_2Na_65SO_4$=40·25 p. c. $CoO+Na_2O$
also gave ·1723 gr. $CoSO_4$=19·86 p. c. CoO=21·98 p. c. Co_2O_3.

·4873 gr. salt gave ·4291 gr. $Co_2Na_65SO_4$=40·20 p. c. $CoO+Na_2O$
also gave ·2012 gr. $CoSO_4$=19·98 p. c. CoO=22·11 p. c. Co_2O_3.

Yellow Salt. 3rd Preparation.

·8554 gr. salt gave ·7354 gr. $Co_2Na_65SO_4$=39·25 p. c. $CoO+Na_2O$
also gave ·3543 gr. $CoSO_4$=20·04 CoO=22·18 p. c. Co_2O_3.

$Co_26NO_2+4(NaNO_2)+H_2O$.			$Co_26NO_2+6(NaNO_2)+H_2O$.			
Theor. p. cts.	Found p. cts.		Theor. p. cts.	Found p. cts.		
Co_2O_3—24·13	23·71	23·21	20·10	20·53	22·04	22·18
Na_2O—18·02	18·37	18·70	22·52	20·70	20·31	19·21
N_2O_3—55·23		47·07 (?)*	55·20			[20·54]
H_2O— 2·62		6·66 (?)*	2·18			

Some error connected with the $CaCl_2$ tube which I am entirely unable to account for has here caused an error. It will be observed that in each case the total loss of the combustion-tube is very nearly what the theor. per cent of H_2O+N would demand, while the increase in the $CaCl_2$ tube is out of all proportion. If we examine the results in the yellow salt, we see that all these preparations are more or less mixtures. The last preparation indeed might be put equally under the head of the 2-atom salt, the per cent in bracket showing the per cent Na_2O calculated on the other formula. We are fortunately, however, not dependant solely on these analyses for our evidences of the existence of these two salts. On account of their partial solubility, we are enabled to obtain substitution compounds from them, which throw very strong light on the composition of the alkali-cobaltic nitrites. In one case, after the formation and filtering off of some of the brown salt, chlorid of luteocobalt was added to the wine-colored filtrate, which

* The found per centages of $N+H_2O$ in the brown salt is the average of two determinations.

probably held some of both salts in solution. The strong tendency which luteocobalt possesses to form double salts suggested to Dr. Gibbs that some results might be here obtained. A beautiful yellow crystalline salt formed and settled quite readily. I then prepared a considerable amount of it for analysis. It proved to be as good as insoluble in cold water, so that its washing was an easy matter. Its analysis shows very clearly that it was formed from the tri-sodio-cobaltic nitrite, or yellow soda salt, which existed in the solution, and that one atom of luteocobalt exactly replaces the three of $Na_2\Theta$, giving it the formula:

$$\mathfrak{C}o_2, 6N\Theta_2 + \mathfrak{C}o_2 12NH_3, 6N\Theta_2 + H_2\Theta.$$

The following are the analytical results:

·5627 gr. salt gave ·3471 gr. $\mathfrak{C}oS\Theta_4$ = 29·85 p. c. $\mathfrak{C}o\Theta$ = 33·03 p. c. $\mathfrak{C}o_2\Theta_3$.

·2867 gr. salt gave ·1770 gr. $\mathfrak{C}oS\Theta_4$ = 29·87 p. c. $\mathfrak{C}o\Theta$ = 33·06 p. c. $\mathfrak{C}o_2\Theta_3$.

·5834 gr. salt gave 176·88 cc. nitrogen at 3° and 661·29 mm. = 32·79 p. c. N. = 19·91 p. c. NH_3 and 44·50 p. c. $N_2\Theta_3$.

1·0866 gr. salt gave with $\mathfrak{C}u + \mathfrak{C}u\Theta + PbCr\Theta_4$ ·3745 gr. = 34·46 p. c. $H_2\Theta$ = 32·09 p. c. from NH_3 + 2·37 p. c. $H_2\Theta$.

$$\mathfrak{C}o_2, 6N\Theta_2 + \mathfrak{C}o_2 12NH_3, 6N\Theta_2 + H_2\Theta.$$

	Theor. p. cts.	Found p. cts.
$\mathfrak{C}o_2\Theta_3$	32·87	33·04
NH_3	— 20·20	19·91
$N_2\Theta_3$	— 45·15	44·50
$H_2\Theta$	— 1·78	2·37

I now tried chlorid of purpureo-cobalt upon some of the same solution and got a roseo-cobalt compound, exactly analogous to that of luteocobalt, its formula being—

$$\mathfrak{C}o_2 6N\Theta_2 + \mathfrak{C}o_2 10NH_3\, 6N\Theta_2 + H_2\Theta.$$

The following were the analytical results:

·3186 gr. salt gave ·1974 gr. $\mathfrak{C}oS\Theta_4$ = 29·98 p. c. $\mathfrak{C}o\Theta$ = 33·18 p. c. $\mathfrak{C}o_2\Theta_3$.

$$\mathfrak{C}o_2, 6N\Theta_2 + \mathfrak{C}o_2 10NH_3, 6N\Theta_2 + H_2\Theta.$$

	Theor. p. ct.	Found p. ct.
$\mathfrak{C}o_2\Theta_3$	— 34·02	33·18

This salt is not nearly as insoluble, however, as the luteocobalt salt and but a little of it could be obtained. At first I got it as a yellow and very crystalline salt on the sides of the beaker, after standing some little time. The crystals examined under the microscope were beautifully defined monoclinic prisms with terminal planes. The portion I analyzed had more of the color

of the salts of roseo-cobalt and showed under the microscope a star-shaped aggregation of small crystals.

I also formed in the soda-salt solution a yellowish xantho-cobalt compound having probably an analogous constitution but did not get enough of it to analyze. Examined under the microscope, the crystals were seen to be of a peculiar cup-shaped appearance and quite large and pointed.

The ammonium salts were next examined. That one at least existed had been found by Gibbs and Genth,* although it had not been analyzed by them. Erdmann† had, however, formed an ammonium salt exactly corresponding to Fischer's salt. I succeeded in forming this and another, the two exactly corresponding in constitution to the two soda salts. The circumstances under which the different salts form I am not able, however, to state at all positively, except that in forming the 3-atom salt I had more concentrated $CoCl_2$ and $NH_4N\Theta_2$ solutions. They are both bright yellow and could not be distinguished by their color. We may term them the *di-ammonio-cobaltic nitrite* and the *tri-ammonio-cobaltic nitrite*, their formulas being respectively

$$Co_2 6N\Theta_2 + 4(NH_4N\Theta_2) + 2H_2\Theta$$

and

$$Co_2 6N\Theta_2 + 6(NH_4N\Theta_2) + 2H_2\Theta.$$

The following were the analytical results:

Two-atom Salt.

·4495 gr. salt gave ·2022 gr. $CoS\Theta_4$ = 21·77 p. c. $Co\Theta$ = 24·09 p. c. $Co_2\Theta_3$.

Three-atom Salt.

·2992 gr. salt gave ·1145 gr. $CoS\Theta_4$ = 18·53 p. c. $Co\Theta$ = 20·51 p. c. $Co_2\Theta_3$.

·4169 gr. salt gave ·1602 gr. $CoS\Theta_4$ = 18·59 p. c. $Co\Theta$ = 20·58 p. c. $Co_2\Theta_3$.

$Co_2 6N\Theta_2 + 4(NH_4N\Theta_2) + 2H_2\Theta$.		$Co_2 6N\Theta_2 + 6(NH_4N\Theta_2) + 2H_2\Theta$.	
Theor. pr. ct.	Found pr. ct.	Theor. pr. ct.	Found pr. ct.
$Co_2\Theta_3$—24·20	24·09	20·39	20·55

Lang is more nearly right in the case of these ammonia compounds than in regard to the soda salts, they being much more soluble. I was unable, however, to obtain any substitution compounds. With this additional light we are now prepared to draw some conclusions. We find that our luteocobalt and roseocobalt compounds are exactly analogous to the cobalticyanids of luteocobalt and roseocobalt formed by Gibbs and Genth,‡ the only difference being that the monatomic radical $N\Theta_2$ here replaces the monatomic radical Cy. This I think

* Researches on Ammonia cobalt bases, p. 48. † Jour. Pr. Ch., xcvii, 405.
‡ Researches on Ammonia cobalt bases, pp. 40, and 18.

gives us a very strong argument in favor of the exact analogy of the 3-atom soda salt and with it of Fischer's salt, to the cobalticyanid of potassium, from which the salts of Gibbs and Genth were formed. With this view of these salts, we are able to discern yet other analogies. Iridium forms a number of sesquioxyd salts very similar to those of cobalt. We have, indeed, two double chlorids of iridium, exactly analogous to the 2-atom and 3-atom soda or ammonia salts. Their formulas are

$$Ir_2Cl_6+4KCl \text{ and } Ir_2Cl_6+6KCl$$

in which we should expect monatomic Cl to be exactly replaceable by monatomic $N\Theta_2$, and so we find that it is. Dr. Gibbs has discovered an iridium salt, having the formula

$$Ir_2 6N\Theta_2+6(KN\Theta_2)+2H_2\Theta,$$

an exact analogue of Fischer's salt. Lang* also has discovered a rhodium salt, whose formula $Rh_2 6N\Theta_2+6(KN\Theta_2)$ is precisely analogous. If we place together for a moment the three salts in question, their identity of constitution becomes apparent.

$Ir_2\Theta_3, 3N_2\Theta_3+3(K_2\Theta, N_2\Theta_3)$ or $Ir_2 6N\Theta_2+6(KN\Theta_2)$—Gibbs.
$Rh_2\Theta_3, 3N_2\Theta_3+3(K_2\Theta, N_2\Theta_3)$ or $Rh_2 6N\Theta_2+6(KN\Theta_2)$—Lang.
$Co_2\Theta_3, 3N_2\Theta_3+3(K_2\Theta, N\Theta_3)$ or $Co_2 6N\Theta_2+6(KN\Theta_2)$—Sadtler.

If, therefore, we are to place any dependence at all upon analogy, the universal occurrence of the hexatomic Co_2 atom in all our compounds, is what we should expect, a priori. The analyses of the series of salts I think fully confirms this expectation.

I have now to discuss some related compounds—those formed in neutral solutions. Erdmann first pointed out the distinction between these and the normal Fischer's salt. He obtained and analyzed a yellow "neutral salt." I obtained one corresponding to this, and one of a different ratio. By adding a somewhat dilute solution of $KN\Theta_2$ to a warm solution of $CoCl_2$, I obtained a highly crystalline precipitate, which was shortly followed by a somewhat crystalline greenish salt, which was again followed after some time by a yellowish precipitate, with little or no crystalline character. The appearances were indicative of the successive formation of three protoxyd compounds. This however, I found was not the case. The black precipitate under the microscope was seen to consist of beautifully defined cubes of a very dark green color, and the green precipitate was seen to consist of similar cubes, though much smaller. Analysis afterward proved them to be the same salt in different states of aggregation. On adding a warm concentrated solution of $KN\Theta_2$, however, to a warm concentrated solution of $CoCl_2$ nothing is formed but a flocculent yellow precipitate, which appears to be the same as that which I formed over mercury in the eudiometer tube. The formulas of these salts appear to be as

* Royal Swedish Acad. Trans., 1864.

follows. For the black or green salt $2(Co2N\Theta_2)+2(KN\Theta_2)+H_2\Theta$ and for the yellow salt $Co2N\Theta_2+2(KN\Theta_2)+H_2\Theta$, and the first may be termed a *potassio-dicobaltous nitrite* and the second a *potassio-mono-cobaltous nitrite.* Appended are the analytical results.

Prep. No. 1.—*Black Salt,* very crystalline.

·5421 gr. salt gave ·5421 gr. $Co_2K_23S\Theta_4$=50·43 p. c. $Co\Theta+K_2\Theta$
also gave ·3425 gr. $CoS\Theta_4$=30·57 p. c. $Co\Theta$.
·7341 gr. salt gave ·7361 gr. $Co_2K_23S\Theta_4$=50·57 p. c. $Co\Theta+K_2\Theta$
also gave ·4662 gr. $CoS\Theta_4$=30·73 p. c. $Co\Theta$.

Prep. No. 2.—*Green Salt* (had not been washed for analysis.

·3003 gr. salt gave ·3063 gr. $Co_2K_23S\Theta_4$=51·44 p. c. $Co\Theta+K_2\Theta$
also gave ·1846 gr. $CoS\Theta_4$=29·74 p. c. $Co\Theta$.
·3221 gr. salt gave ·3286 gr. $Co_2K_23S\Theta_4$=51·45 p. c. $Co\Theta+K_2\Theta$
also gave ·1971 gr. $CoS\Theta_4$=29·61 p. c. $Co\Theta$.

Prep. No. 3.—*Black and Green Salts mixed,* very crystalline.

·6942 gr. salt gave ·6978 gr. $Co_2K\ 3S\Theta^4$=50·70 p. c. $Co\Theta+_2K\Theta$
also gave ·4410 gr. $CoS\Theta_4$=30·74 p. c. $Co\Theta$.
·4713 gr. salt gave ·4730 gr. $Co_2K_23S\Theta_4$=50·62 p. c. $Co\Theta=K_2\Theta$
also gave ·3004 gr. $CoS\Theta_4$=30·84 p. c. $Co\Theta$.

Prep. No. 1.—*Yellow Salt.*

·2702 gr. salt gave ·2631 gr. $CoK_22S\Theta_4$=50·05 p. c. $Co\Theta+K_2\Theta$
also gave ·1235 gr. $CoS\Theta_4$=22·12 p. c. $Co\Theta$.
·4615 gr. salt gave ·4497 gr. $CoK_22S\Theta_4$=50·08 p. c. $Co\Theta+K_2\Theta$
also gave ·2103 gr. $CoS\Theta_4$=22·05 p. c. $Co\Theta$.

$2(Co2N\Theta_2)+2(KN\Theta_2)+H_2\Theta$.				$Co2N\Theta_2+2(KN\Theta_2)+H_2\Theta$	
Theor. p. cts.	Found p. c. cts.			Theor. p. cts.	Found p. cts.
$Co\Theta$—30·60	30·65	29·67	30·79	22·11	22·08
$K_2\Theta$—19·22	19·85	21·78	19·87	27·77	27·09
$N_4\Theta$ —46·51				44·80	
$H_2\Theta$— 3·67				5·31	

In looking over the analytical data of these analyses of protoxyd salts, we notice a striking similarity between the weights of salt taken and weights of double sulphates obtained. The explanation is very simple, and yet I believe there is involved in it a fact of importance. The similarity of weights is due to the similarity of atomic weights of $N_2\Theta_3$ and $S\Theta_3$ (76 and 80) with which the bases are combined. Now in none of the very many determinations made in the "acid salts," do we find such a similarity. On the contrary we find the weight of double sulphates to be invariably less than the weight of salt taken and in a fixed ratio. The explanation of this is that $Co_2\Theta_33N_2\Theta_3$ by digestion with $H_2S\Theta$ is converted into two atoms of neutral $CoS\Theta^4$ and becomes $2(CoS\Theta_4)$. $2Co\Theta, 2N_2\Theta_3$ simply assumes

$S\Theta_3$ instead of $N_2\Theta_3$ and becomes likewise $2(\mathfrak{C}oS\Theta_4)$. The first loses and atom of $N\Theta_2$ which the second does not. We have here a strong evidence of the totally different habitus of the $\mathfrak{C}o$ atom in the "neutral" and in the "acid" salts.

Having now made a complete statement of all my analytical results in the case of Fischer's salt proper, as well as in this series of analogous and related compounds, which I have described in this connection, and noticed the conclusions to be drawn from them, before summing up my argument, I will examine how the results of Stromeyer, Erdmann and Braun compare with my own. In the first case I think the last argument drawn from the similarity of weights of double nitrite and double sulphate in the protoxyd salts and the difference of weights of double nitrite and double sulphate in the sesquioxyd salts, effectually precludes our assigning a formula like that of Stromeyer, in which $2(N_2\Theta_3)$ combines with $\mathfrak{C}o_2\Theta_3$, to the normal Fischer's salt. The salt Stromeyer analyzed was probably a mixture of "acid" and "neutral" salts, as he speaks of adding "a little acetic acid." It is easily seen that a mixture of the "acid salt" and the yellow "neutral salt" would give figures approximating to his. Erdmann's results correspond in the main to the analysis of my second preparation. The only difference then is that I have introduced a generalization, which I think my figures fully justify. With Braun's results, I am hardly able to make a comparison, as he made his preparation in a manner totally different from that followed by either Erdmann or myself. His formulas, as might be inferred from my statement of them in the beginning of this paper, I am still less able to accept.

To sum up briefly, the reasons for regarding Fischer's salt as a potassio-cobaltic nitrite, having the essential formula

$$\mathfrak{C}o_26N\Theta_2+6(KN\Theta)+aq.$$ are—

1st. The liberation of Θ at the moment of its formation and the rapidity with which, under these circumstances, the salt forms, would seem to justify the assumption.

2nd. The analyses of six distinct preparations sustain it.

3rd. The existence of corresponding sodic and ammonic salts is proved by analysis.

4th. The formation of substitution compounds exactly analogous to well known salts is proved by analysis.

5th. The analogy of Fischer's salt to double cyanids, chlorids and nitrites proved to contain a similar hexatomic atom.

6th. The difference of ratio between the weights in the protoxyd and sesquioxyd salts is marked and constant throughout.

Accepting these proofs, we will sum up with equal brevity the formulas of the salts analyzed on this view:—

Tri-potassio-cobaltic nitrite, $Co_2 6NO_2 + 6(KNO_2) + aq.$
Di-sodio-cobaltic nitrite, $Co_2 6NO_2 + 4(NaNO_2) + H_2O.$
Tri-sodio-cobaltic nitrite, $Co_2 6NO_2 + 6(NaNO_2) + H_2O.$
Di-ammonio-cobaltic nitrite, $Co_3 6NO_2 + 4(NH_4NO_2) + 2H_2O.$
Tri-ammonio-cobaltic nitrite, $Co_2 6NO_2 + 6(NH_4NO_2) + 2H_2O.$
Luteocobaltio-cobaltic nitrite, $Co 26NO_2 + Co_2 12NH_3, 6NO_2 + H_2O.$
Roseocobaltio-cobaltic nitrite, $Co_2 6NO_2 + Co_2 10NH_3, 6NO_2 + H_2O.$
Xanthocobaltio-cobaltic nitrite,
Potassio-dicobaltous nitrite, $2(Co 2NO_2) + 2(KNO_2) + H_2O.$
Potassio-monocobaltous nitrite, $Co_2NO_2 + 2(KNO_2) + H_2O.$

These it will be seen are capable of ready conversion into atomic formulas, thus: $Co_2^{VI}[K(NO_2)_2]6$ and $Co_2^{VI}[(Na(NO_2)_2)_2\ (NO_2)_4]$ and so on.

In the course of my examination of these salts, I had an opportunity of comparing the relative merits of the different analytical methods employed. A brief statement in regard to them may be of some value.

1st. Determination of Co and K. The double sulphate method already alluded to, was first proposed by Gibbs and Genth,* and I find it to give extremely close results. Sulphuric acid is added to the weighed portion of the salt in a porcelain crucible, which is then heated carefully, either by a ring gas burner from above, or by radiation while supported in a sheet-iron crucible. After the nitrous acid is all driven off with most of the excess of sulphuric acid, the sulphates begin to fuse and as the last trace of sulphuric acid goes off, they pass into calm fusion. They will then bear a very considerable increase of heat without farther decomposition. I found this method capable of extension to both the soda salts, as well as to the protoxyd salts, the double sulphates formed having of course a constitution depending upon the proportion of the bases in the original salts. The soda sulphates did not appear, however, to possess as perfect a fusibility as the double potash sulphate from Fischer's salt, while the double sulphates from the protoxyd potash salts were also less fusible, in proportion to their greater ratio of Co. I give an instance in proof of the accuracy of this method. Four determinations of $CoO + K_2O$ were made in preparation No. 6 of Fischer's salt in the manner described. The percentages of double oxyds were 48·71, 48·69, 48·66, 48·71. This method was tried by Gauhe† without obtaining good results. Several points are to be noticed however. The salt in which Gauhe sought to verify the composition of the double sulphate was plainly a mixture of "acid" and "neutral" salt. He says, "after some days small amounts deposited." This was before Erdmann's paper had appeared.

* Researches on Ammonia cobalt bases, p. 49.
† Zeitsch. Anal. Ch., iv, p. 56.

Again, Gauhe will find that Gibbs and Genth never even mentioned the use of $(NH_4)_2CO_3$ in this connection, so that his experiments were plainly made under different conditions from those proposed.

2d. Determination of Co. I prefer to determine Co as neutral $CoSO_4$. We have the advantage here of determining the Co in the form of a compound of higher atomic weight, thus lessening our errors of analysis. The cobalt is precipitated from the solution of the double sulphates as CoS, washed with hot sulphid of ammonium water, dried and roasted and then converted into sulphate with the aid of aqua regia and sulphuric acid. The results are good, although not so exact as in the case of the fusible double sulphates. I also determined Co as metal by H after its precipitation as hydrated oxyd by Cl and acetate of soda, a method proposed by Popp.* Instead of Cl I found it far more convenient in practice to use a strong solution of Cl_2O_4, which is a powerful oxydizing agent, and as it can be kept, becomes a useful laboratory reagent. This method, however, does not always give good results, on account of the difficulty of washing the hydrated Co_2O_3 till free from alkali.

3d. Determination of the N. This was done, first by the modification of Bunsen's† method proposed by Dr. W. Gibbs,‡ which space will not permit me to give in detail. The reader is therefore referred to the original paper. Suffice it to say, that for nitrates and nitrites to which it is applicable, it is an excellent method. The loss of the combustion-tube can be nothing but N and H_2O. If, therefore, the $CaCl_2$ tube retains the H_2O accurately, the remainder is N. Whether, therefore, the H_2O is accurate, or high from hygroscopic moisture, the nitrogen must be accurate, being subject to no source of error.

The nitrogen was also determined by volume, using the Sprengel-pump. This method was first proposed by Frankland§ for nitrogen in analyses of potable waters, but he did not apply it then to organic analysis. The application, however, had been made in this laboratory by Dr. Gibbs some months before Dr. Frankland's paper was received. A vacuum is first made in the combustion-tube by means of the mercury-pump. The delivery-tube from the pump is then connected with a Simpson's receiver and the vacuum destroyed by heating some CO_2 placed in the anterior portion of the tube. Any excess of CO_2 is absorbed by the KHO solution in the receiver. The combustion is now made. A final vacuum is then obtained by the pump and the receiver disconnected. After a short time the gas is transferred to a eudiometer-tube and measured according to the methods of gas-analysis. The results are generally good, but depend upon

* Ann. Ch. u. Ph., 131, 363.
‡ This Jour., xxxvii, 350.
† Ann. Ch. u. Ph., 72, 40.
§ Jour. Ch. Soc., 1868, p. 90.

the vacuum obtained at the beginning and end, on the perfect combustion, and on the perfect transfer of the gas.

In conclusion I would present my grateful acknowledgments to Dr. W. Gibbs, to whose kindness I am indebted for the selection of my subject, for the use of materials, and for many valuable suggestions during the prosecution of my work.

Cambridge, Jan., 1870.

ART. XXV.—*Notice of some Fossil Birds, from the Cretaceous and Tertiary Formations of the United States;* by O. C. MARSH, Professor of Paleontology in Yale College.

The remains of Birds described from European rocks are at present limited in the Mesozoic to the famous *Archæopteryx* of the Jurassic, and apparently a single species only from the Cretaceous; but in the Tertiary period, and especially in the Miocene and Pliocene, this class was very fully represented by many of the modern types, and numerous species have already been described by Owen, von Meyer, Gervais, Hébert, Lartet, Gaudry, A. Milne-Edwards, and other paleontologists. In this country, however, since the discovery that the three-toed footprints in the Connecticut river sandstone were probably all made by Dinosaurian reptiles, no species of birds have been included in our extinct fauna, as, with this apparent exception, none have been described from any North American strata. Recent explorations, however, have shown that remains of this class are not wanting in the later formations of the United States, and that the Cretaceous and Tertiary, especially, contain representatives of many interesting forms.

The bones of birds, as might naturally be expected, are usually the rarest of vertebrate fossils, particularly in marine deposits; but, fortunately, those parts of the skeleton most likely to be preserved are especially characteristic, so that even small portions not unfrequently admit of accurate determination, although their investigation is a work of considerable difficulty, even where ample material for comparison with recent species is available. The specimens briefly described in the present preliminary notice, although nearly all fragmentary, are in an excellent state of preservation; and most of them show strongly marked characters, which indicate at least the near affinities of the species they represent. If the interpretation of them here given be correct, they prove the existence, in this country, even before the close of the Mesozoic, of an interesting and varied group of aquatic birds, and suggest for this period a very rich avine fauna.

Remains of Cretaceous Birds.

Among the fossils under consideration are specimens indicating five species of Cretaceous birds, the remains of which were found in the greensand of New Jersey, and with a single exception in the middle marl bed. The specimens are all mineralized, and in the same state of preservation as the bones of the extinct reptiles which occur with them in these deposits; and hence are readily distinguished from the remains of Post-tertiary and recent birds, which have occasionally been found near the surface in the greensand excavations of that region. In most instances, moreover, a record of the discovery places the geological horizon of the present fossils beyond a doubt.

Laornis Edvardsianus Marsh, gen. et sp. nov.

The most interesting, in many respects, of the specimens from the Cretaceous is a portion of the shaft and distal extremity of a left tibia, which indicates a species, apparently of a swimming bird, nearly as large as the common wild swan (*Cygnus Americanus* Sharpless). The specimen is well preserved, and shows that the tibia, when entire, was of medium length, and quite robust. The condyles of the distal end are broader anteriorily than deep, the inner condyle being more prominent in front, and the outer one projecting somewhat farther behind. The inter-condyloid space is wider than either condyle. The supratendinal bridge—one of the most characteristic portions of the skeleton, when present—is well ossified, and still uninjured. It is submedial in position, straight, transverse, of moderate width, and spans a deep and well defined canal, which was traversed by the extensor tendon of the toes. The outer margin of the canal is low and obtuse, as in most of the Gallinaceous birds. The inner margin is the more prominent, and just above the upper edge of the bridge it supports an elongated tubercle for the inner attachment of the oblique ligament. Opposite the bridge, on the other margin, there is a large triangular elevation, which is separated by a shallow transverse groove from the exterior condyle. To this prominence the outer end of the oblique ligament was attached. The outlet of the canal above the bridge is transversely elliptical in outline, and the one below more oval, and looking forward, and slightly outward. Just below this aperture, there is a shallow depression in the inter-condyloid space, similar in shape and position to that in the tibia of the wild goose (*Bernicla Canadensis* Boie), although rather deeper, and more oblique. The under trochlear surface is but slightly concave transversely, and has a faint median elevation, as in the tibia of the swan; but in the present specimen this is continued along the entire posterior surface, which is broad, with a slight, transverse concavity. On the lower surface

of the inner condylar ridge there is a shallow notch, resembling in shape and position that in the tibia of some of the Gulls, especially the Herring Gull (*Larus argentatus* Brünn.). The ecto-condyloid surface is unusually circular in outline, and has, for the attachment of the external, articular ligament, a low tubercle, a little behind and below its central point. Just in front of this, there is a shallow groove extending directly upward. The ento-condyloid surface is moderately transverse, and has on its anterior portion, for the attachment of the internal ligament, a large irregular tubercle, which is connected by a low ridge with the prominent inner margin of the tendinal canal. A portion of the fibular ridge remains on the upper part of the specimen, and a faint indication of its continuation can be traced nearly to the ecto-condyloid surface, where it passes into a small, acute, elongated tubercle, which is just outside of the triangular prominence, already mentioned. Between these two elevations, there is a deep groove for the tendon of the short tibial muscle, and in its inner margin a small elongated foramen, leading obliquely downward and inward.

The portion of the shaft preserved is robust, and somewhat flattened in an antero-posterior direction. In the lower fourth of the bone, the transverse diameter gradually increases, and reaches its maximum at the extremity of the distal condyles. The shaft curves forward slightly just where it begins to expand above the lower condyles, closely resembling in this respect the tibia of the turkey; and it has at this point little of the marked inward curvature, characteristic of the swimming birds, but is so straight, that its median plane, if continued, would divide the trochlear surface nearly equally.

The dimensions of the specimen are as follows:—

Length of portion preserved, . . .	70·mm·
Width of condyles in front, . . .	23·
Depth of outer condyle, ...	19·1
Width of bridge at center, . . .	5·2
Transverse diameter of upper outlet, . .	5·
Transverse diameter of lower outlet, . .	4·4
Transverse diameter of shaft where broken, .	11·8
Antero-posterior diameter of shaft where broken,	9·6

A consideration of the characteristic points of this interesting fossil leads to the conclusion that it should be placed in the order *Natatores*, but additional remains will probably be required to determine its exact affinities. It shows a strong resemblance in several respects to the *Lamellirostres*, and also to the *Longipennes*, but differs essentially from the typical forms of both these groups. For the extinct genus evidently represented by this specimen the name *Laornis** is proposed. The

* Λᾶος, *stone*, and Ὄρνις, *bird*.

species may very justly be named *Laornis Edvardsianus*, in honor of M. Alphonse Milne-Edwards, of Paris, whose great work on Fossil Birds, now in course of publication, promises to place this hitherto neglected branch of paleontology on a firm foundation.*

This unique specimen was found in the greensand of the upper, Cretaceous marl bed, at Birmingham, New Jersey, in the pits of the Pemberton Marl Company, and was presented to the Museum of Yale College by the superintendent, J. C. Gaskill, Esq.

Palæotringa littoralis Marsh, gen. et sp. nov.

The present collection contains, also, some remains of wading birds from the Cretaceous, and among them are specimens indicating two species, apparently belonging to the *Grallæ*. Each of these is represented by a portion of the shaft, and the lower extremity of a left tibia, and probably by some other fragmentary, but less characteristic parts of the skeleton. The tibia of the larger species resembles in size and general form that of the European Curlew (*Numenius arquata* Linn.). The condyles of the distal end are expanded anteriorly, but in their posterior extension continue upward as acute, prominent ridges. The inner condyle is somewhat narrower than the outer. The intercondyloid space is smooth, with the exception of a faint transverse groove, and is wider than either condyle. The trochlear surface is broad, slightly concave transversely, and its median portion nearly flat, especially at the extremity. Its upper, posterior surface projects slightly beyond the face of the adjoining shaft. The ecto-condyloid surface is smooth, and somewhat concave. The supratendinal bridge is narrow, very thin, transverse, and has its outer edge on the median line. The tendinal canal is very broad and deep, and its floor nearly flat. In its general features it resembles the canal of the Herring, or Silvery Gull. The aperture below the bridge is oval in outline, and looks forward, and slightly inward and downward. On the outer margin of the canal, just above the exterior condyle, there is a triangular rugose surface, to which the oblique ligament was apparently attached. This surface projects outward, so as to produce a slight swelling at this point on the side of the shaft. The interior margin of the canal is the more acute, and just above the bridge has on its inner edge a small elongated and inflected tubercle for the attachment of the upper end of the oblique ligament.

The shaft of the tibia is slender, and has its narrowest part at the beginning of the lowest fourth, or a little above where the margins of the tendinal canal begin. From this point

* Recherches sur les Oiseaux Fossiles de la France. 4to. Paris, 1867–70.

downward, the shaft curves slightly forward, and also expands transversely, but much more gradually than in most wading birds. The lower half of the tibia is unusually flat in front, and very convex behind. A transverse section of the broken end is broadly oval.

The admeasurements of this tibia are as follows:—

Length of portion preserved,	43·5mm.
Width of condyles in front,	9·7
Depth of outer condyle,	8·6
Width of bridge at center,	1·6
Transverse diameter of upper outlet,	2·
Transverse diameter of lower outlet,	1·9
Transverse diameter of shaft where broken,	4·7
Antero-posterior diameter of shaft where broken,	3·8

The remains on which this species is established are from the Cretaceous greensand of the middle marl bed. They were discovered by Nicholas Waln, Esq., in his marl pits, at Hornerstown, New Jersey, and by him presented to the Museum of Yale College.

Palæotringa vetus Marsh, sp. nov.

The present species is indicated by the lower portion of a right tibia, which is of peculiar interest, as it apparently was the first fossil bird-bone discovered in this country. It is mentioned by Dr. Morton in his Synopsis, as "the tibia of a bird belonging to the genus *Scolopax;*"* and subsequently by Dr. Harlan, who regarded it as the femur of a bird allied to the same genus.† The specimen has since remained in the collection of the Academy of Natural Sciences in Philadelphia, but no description of it has been published, probably owing to the fact that it has generally been regarded as a recent species, accidentally introduced into the deposit where found. It is, however, thoroughly fossilized, and in precisely the same state of preservation as the remains of birds, since discovered in the same region, which are known to be of Cretaceous age, and hence its antiquity cannot now be fairly called in question.

This specimen indicates a species about half the size of *P. littoralis*, or about as large as the Hudsonian Godwit (*Limosa Hudsonica* Swain.). In general form and proportions it closely resembles the tibia just described. This is especially evident in the very gradual, transverse expansion of the lower end of the tibia; and in the broad concave trochlear surface, with no indications of a median elevation, or of the peculiar flattening of the inferior surface, which is seen in many of the Snipe family.

* Synopsis of the Organic Remains of the Cretaceous of the U. S., p. 32, Philadelphia, 1834.

† Medical and Physical Researches, p. 280, Philadelphia, 1835.

One of the most important differences between them, however, is in the supra-tendinal bridge, which in the present specimen is broader and stouter, and the outlet below looks more directly forward. The inter-condyloid space, also, has a distinct transverse depression, which is but faintly indicated in the former specimen. The rugose surface on the outer margin of the canal is here replaced by three tubercles, the largest of these, to which the oblique ligament was doubtless attached, being nearly opposite the bridge, and the other two above and outside of it. The anterior face of the tibia above the bridge is nearly flat, with a faint median rising, which throws the true tendinal canal against its inner margin. In the previous specimen this elevation does not exist, the corresponding space being transversely concave. The ecto-condyloid surface in this species is almost flat, with a slight elevation just below its central point. The ento-condyloid face is quite concave posteriorly, but near the middle of its anterior projection has a very small tubercle for the attachment of the lateral, articular ligament.

The principal dimensions of this tibia are as follows:—

Length of portion preserved,	18·5^{mm}.
Width of condyles in front,	7·2
Depth of outer condyle,	4·9
Depth of inner condyle,	6.6
Width of bridge at center,	1·8
Transverse diameter of shaft where broken,	3·4

The differences noted above between this specimen and the tibia of *P. littoralis* render it probable that additional remains would show that they belong to distinct genera; but for the present they may very properly be placed together in the genus *Palæotringa*,* and the present species be named *Palæotringa vetus*. The specimen, according to the authorities already cited, was found in the marl at Arneytown, New Jersey, which would imply that it was from the lowest, Cretaceous marl bed.

Telmatornis priscus Marsh, gen. et sp. nov.

The most important of the remains on which this species is founded is the lower half of a left humerus. The specimen is in perfect preservation, and, fortunately, a very characteristic part of the skeleton. In general appearance it resembles the humerus of some of the Rail family, and the species it represents is probably related to this group of birds. Evidence of this is seen in the unusual flattening of the lower part of the shaft and distal extremity; in the small articular condyles; in the diminutive protuberance for the attachment of the extensor muscle of the hand; and in the oval impression of the anterior brachial muscle. The latter has, however, in this

*Παλαιός, *ancient*, and Τρύγγας, *a shore bird*, mentioned by Aristotle.

specimen a more oblique position than in most of the *Rallidæ*. It resembles the corresponding impression in the woodcock, (*Philohela minor* Gray), but is situated higher up, and its superior margin is less distinctly defined. The distal end of this humerus resembles in its main features that of the Green Heron (*Butorides virescens* Bonap.), but differs widely from it in being much more compressed, and in having the imprint of the anterior brachial muscle much shorter, and more oblique.

The most important dimensions of this humerus are as follows:

Length of specimen preserved,	25·mm·
Vertical diameter of distal end,	11·2
Transverse diameter through radial condyle,	5·6
Depth of shaft where broken,	4·4
Transverse diameter of shaft where broken,	3·6
Length of impression of anterior brachial muscle,	5·8

These remains apparently indicate a genus of birds distinct from any yet described, for which the name *Telmatornis** is proposed. The present species, which was about the size of the King Rail (*Rallus elegans* Aud.), may be called *Telmatornis priscus*. The remains of the species at present known were found in the Cretaceous greensand of the middle marl bed, in pits of the Cream Ridge Marl Company, near Hornerstown, New Jersey, and were presented to the Museum of Yale College by John G. Meirs, Esq.

Telmatornis affinis Marsh, sp. nov.

This species is also based, essentially, on the lower portion of a right humerus, which was found at the same locality, and in the same stratum as the one just described. It closely resembles that specimen in most important particulars, but a careful comparison shows some points of difference which appear to justify its separation. The most apparent of these are the following:—The notch between the radial and ulnar condyles is somewhat deeper; the elongated tubercle, on the inner surface behind the notch, which confines the upper tendon of the triceps muscle, is larger; the impression of the anterior brachial muscle on the outer surface is higher up, and more shallow; and the epitrochlear elevation is more prominent. The specimen indicates, moreover, a species considerably smaller than the one mentioned above. Its principal measurements are as follows:—

Length of portion preserved,	12·mm·
Vertical diameter of distal end,	10·4
Transverse diameter through radial condyle,	4·8
Vertical diameter of shaft where broken,	5·6
Length of impression of anterior brachial muscle,	5·8

*Τέλμα, *marsh*, and Ὄρνις, *bird*.

These remains, also, were found by John G. Meirs, Esq., near Hornerstown, New Jersey, and by him presented to Yale College, in behalf of the Cream Ridge Marl Company.

Remains of Tertiary Birds.

The few remains of birds hitherto discovered in the Tertiary deposits of the United States naturally show a much closer resemblance to recent species than those from the Cretaceous. In the specimens examined by the writer during the present investigation, which include, it is believed, all the remains of importance known from the formation in this country, no characters implying genera distinct from existing birds are apparent, and some of the fossils seem to indicate species nearly related to those now living. Future discoveries, however, will doubtless disclose more important differences between faunæ so remote in time.

Puffinus Conradi Marsh, sp. nov.

The collection of the Academy of Natural Sciences in Philadelphia has for many years contained the distal half of a left humerus, and the lower portion of a right ulna, of an aquatic bird, which were discovered in the Miocene of Maryland by T. A. Conrad, Esq. A brief mention of these specimens, and of some other ornithic remains from the United States, has already been made by Professor Leidy,* but no description of them has yet been published. The specimens are so well preserved, and so characteristic, especially the humerus, that the affinities of the species they indicate can be determined with tolerable certainty. The most marked feature of the humerus is the transverse obliquity of its shaft and distal extremity. Both are much compressed, and so turned that the common plane of their longer diameters, instead of being nearly vertical, as in the brachium of most birds, is here highly inclined inward and downward. Among the other characters of importance may be mentioned, the unusually small size of the ulnar condyle, the very deep, oval impression for the attachment of the anterior brachial muscle, and the presence of an elongated, compressed apophysis, extending outward and upward from the exterior margin of the distal end, just in front of the radial condyle.

This humerus has the following dimensions:—

Length of portion preserved,	49· mm.
Vertical diameter of distal extremity,	13·2
Transverse diameter of radial condyle,	8·6
Transverse diameter of ulnar condyle,	3·8
Length of impression of anterior brachial muscle,	5·6
Breadth of impression of anterior brachial muscle,	3·8
Longer diameter of shaft where broken,	7·4
Shorter diameter of shaft where broken,	5·

* Proceedings Acad. Nat. Sciences, Philadelphia, 1866, p. 237.

A comparison of the present fossils with the corresponding parts of recent birds readily shows that the nearest allies of this extinct species must be sought in the Auk family, or among the Petrels; as it is only in these groups of birds, that the peculiar obliquity of the humerus, noticed above, exists. In the *Alcidæ*, however, this oblique compression is greater than in the present specimen. The latter has, moreover, on its outer edge above the radial condyle, the long, pointed projection, which is not seen in the Auks, although present in the Petrels, Gulls, and some of the wading birds. The difference in size between the ulnar and radial condyles, and the remarkably deep, oval, impression for the attachment of the anterior brachial muscle show unmistakably that this humerus belongs to one of the Shearwaters, and apparently should be placed in the genus *Puffinus*, with which it corresponds in all essential particulars. In size and general features it apparently resembles most nearly the brachium of the Cinereous Petrel (*Puffinus cinereus* Gmelin, sp.), of the Pacific coast, but there are some points of difference between them which clearly imply that the species are distinct. The flat apophysis on the outer edge of the distal extremity is in the fossil specimen more pointed; the impression, on the lower surface, of the anterior brachial muscle is deeper, and its outline more sharply defined, which is also the case with the small epicondylar depressions for the attachment of the muscles of the forearm. The bone indicates, moreover, a somewhat smaller bird.

The distal half of the right ulna, which was found with the humerus, apparently belonged to a bird of the same species, although its size would seem to indicate that it pertained to a smaller individual. The species represented by these remains may appropriately be named for its discoverer, T. A. Conrad, Esq., who has been so long and honorably identified with American paleontology.

Catarractes antiquus Marsh, sp. nov.

Among the other bird remains in the Museum of the Philadelphia Academy, is a very perfect left humerus, from Tarborough, Edgecombe county, North Carolina, which was presented by Dr. Booth. The geological position of the specimen is not definitely known, but its state of preservation and mineralization render it extremely probable, at least, that it is from the Tertiary deposits of that region. This humerus shows the same transverse obliquity which characterized the specimen just described, and so strongly resembles in other respects also the same bone in the Auks, that it should evidently be referred to that family. It approaches most nearly the humerus of the Guillemots, especially those now included in the genus *Catar-*

ractes, with which it appears to coincide in all important characters.

The principal dimensions of this humerus are as follows:

Total length,	96·2mm.
Transverse diameter of proximal end,	21·
Vertical diameter of articular head,	14·2
Transverse diameter of articular head,	8·2
Vertical diameter of distal end,	13·8
Longer diameter of shaft at center,	8·4
Shorter diameter of shaft at center,	5·

The present specimen shows so many points of resemblance to the humerus of the Thicked-billed Guillemot (*Catarractes lomvia* Linn.), that it will probably find in this species its nearest living representative. It indicates, however, a somewhat larger bird; and on carefully comparing the humeri of the two, some marked differences may be detected, which are quite sufficient to prove the species distinct. The most important of these are the following:—The head of the humerus in the fossil specimen is more obtusely rounded, both transversely and vertically; the two grooves, on the inner surface of the distal extremity, for the tendons of the triceps muscle, are of nearly equal width, the upper depression being somewhat wider than the other, but in *C. lomvia* Linn. the lower groove is much the broader; the ulnar condyle has, moreover, on its interior surface, a small obtuse tubercle, extending upward and inward, as in the humerus of the Great Auk (*Alca impennis* Linn.), while this projection is wanting in the Thicked-billed Guillemot; the lower face of the same condyle also differs from that of the latter species in forming a much narrower crescent; and in several minor points of structure a similar want of correspondence may be seen.

A right humerus, closely resembling the preceding specimen, and evidently belonging to the same genus, was presented to the Philadelphia Academy a few years since by Dr. A. C. Hamlin, who obtained it in the Post-tertiary clays, near Bangor, Maine, at a depth of forty-seven feet below the surface. It appears to be distinct from the above species, as well as from *C. lomvia* Linn., and will be described at an early day by the writer, in a paper now in course of preparation on the remains of some Quaternary birds.

Grus Haydeni Marsh, sp. nov.

The various explorations that have been made in the Tertiary deposits of the Upper Missouri region, so remarkably rich in mammalian remains, have, strange to say, brought to light but a single fragmentary specimen which can with certainty be referred to the class of birds; although the material collected

there has been carefully examined for these fossils by several paleontologists. The only specimen hitherto detected was obtained by Dr. F. V. Hayden, several years since, in the later Tertiary beds of the Niobrara river. It is the distal extremity of a left tibia, one of the most common, and most characteristic parts of fossil birds, and indicates unmistakably a large species of the genus *Grus*, or Cranes. Although the specimen is somewhat injured, the most important parts are well preserved, and appear to exhibit good distinctive characters. The inner articular condyle is partially broken away, but was evidently much narrower than the other, and is continued far backward as a very sharp ridge. The outer condyle is somewhat flattened below, and its posterior extension projects beyond the surface of the shaft, although not so far as that of the inner condyle. The trochlear space is rather narrow, and has its deepest part inside of the median line. It is slightly concave transversely below, and deeply so posteriorly. The ecto-condyloid surface is concave, but has a low tubercle just in front of its central point. The supratendinal bridge is very broad, internal, transverse, and its surface is concave vertically. It spans a very narrow, but deep, internal canal. The lower outlet is subtriangular in outline, and looks obliquely forward and downward. The superior aperture is broadly oval, and the upper edge of the bridge is continued slightly above it on either side of the canal. The lower opening has its upper, straight margin slightly rounded, and its lower edge is formed by a sharp ridge, which separates it from the nearly flat intercondyloid space. External to this aperture is a prominent tubercle, which has its inner edge on the median line, and is connected above by a low ridge with the outer elongated tubercle for the attachment of the oblique ligament. A more prominent crest extends obliquely downward, and unites it with the external condyle. The inner margin of the canal is bounded by a well defined ridge, which, just above the bridge, is inflected over the edge. Externally, the margin of the canal is low, and indistinct. The groove for the tendon of the short tibial muscle is well defined, and bounded outwardly by a low ridge, which causes a projection on the exterior surface of the shaft.

The principal dimensions of this specimen are as follows:—

	mm.
Length of portion preserved,	31·
Depth of external condyle,	19·2
Width of supratendinal bridge,	7·2
Width of upper outlet,	2·4
Width of lower outlet,	3·6
Transverse diameter of shaft where broken,	12·6
Antero-posterior diameter of shaft where broken,	8·2

This specimen, also, belongs to the Academy of Natural

Sciences in Philadelphia, and the extinct species it indicates is named for Dr. F. V. Hayden, whose explorations have added so much to our knowledge of the geology of the Upper Missouri, and Rocky Mountain regions.

Graculus Idahensis Marsh, sp. nov.

A collection of Tertiary fossils from Idaho, lately received by Professor Newberry, of Columbia College, contained the greater portion of the left metacarpal bone of an aquatic bird, which he has kindly loaned to the writer for examination. The specimen is in perfect preservation, and has such marked characters that it will evidently admit of at least approximate determination. Among the most prominent features of the fossil, at its proximal extremity, are, the great anterior projection of the radial apophysis, which is also elevated, and its superior portion considerably compressed; the deep anterior carpal fossa, which extends into the base of the carpal articular surface; the very deep and narrow posterior carpal fossa, which is auriform in outline, and extends obliquely inward and forward; and the internal and oblique position of the smaller metacarpal bone. The pisiform tubercle on the inner surface is of medium size, and its summit nearly flat. A sharp ridge extends from its anterior edge directly upward to the margin of the articular surface. The groove in front of this tubercle is very deep and broad. The fossa for the attachment of the inner lateral ligament of the wrist is also deep, and has, apparently, a small pneumatic opening near its center. The smaller branch of the metacarpal bone was slender, and but little separated from the larger one. Its outer edge at its superior attachment is on the median line, and opposite to this point, on the outer posterior edge of the large metacarpal, there is a small tubercle, to which the superior flexor muscle of the hand was attached. The lower extremity of the specimen has, unfortunately, been lost.

The principal dimensions of this metacarpal bone are as follows:—

Length of portion preserved,	45·mm·
Transverse diameter of proximal extremity,	16·2
Diameter through pisiform tubercle,	8·1
Width of carpal articular surface,	7·2
Length of radial apophysis,	12·
Distance from inner superior edge to union of metacarpals,	18·6
Greater diameter of large shaft where broken,	5·4

The species represented by this fossil appears to have been related to the Cormorants, and may be placed provisionally in the genus *Graculus;* the metacarpal of which the present speci-

men resembles in nearly all important particulars. The most marked difference between them is the presence in the latter of the anterior carpal fossa. This interesting specimen, the only fossil bird bone yet found west of the Rocky Mountains, is from a fresh-water Tertiary deposit, probably of Pliocene age, on Castle Creek, Idaho Territory.

In addition to the acknowledgments made in the course of the present article, the writer desires, in conclusion, to express his grateful thanks to Professor Joseph Leidy, of Philadelphia, who generously placed in his hands for examination the various bird remains already mentioned as belonging to the Academy of Natural Sciences in that city. A more complete description, with illustrations, of all the remains here briefly noticed, and a determination of their nearer relations to living species, as well as the conclusions their discovery suggests, are reserved for a future communication.

Yale College, New Haven, Conn., Feb. 1st, 1870.

ART. XXVI.—*Contributions to Zoölogy from the Museum of Yale College.* No. VI.—*Descriptions of Shells from the Gulf of California;* by A. E. VERRILL.

HAVING in preparation faunal catalogues of the extensive collections of mollusca in the Museum of Yale College, collected in the Gulf of California by Capt. J. Pedersen, and at Panama, San Salvador, Peru, and other localities on the West Coast of America by Prof. F. H. Bradley, it seems useful to notice here some of the more interesting and new species. These will hereafter be more fully described and figured in the Transactions of the Connecticut Academy. Most of the following species were obtained by pearl divers near La Paz.

Semele Junonia Verrill, sp. nov.

A large, broad, somewhat oval species; anteriorly much prolonged and broadly rounded; posteriorly shortened, strongly plicated, the extremity broadly obliquely truncate. Surface covered with regular, nearly equidistant, elevated, strong, concentric lamellæ, which are not close, except near the umboes, but beyond the plication become fainter, oblique, and parallel with the truncated posterior edge; interstices broadly concave, smooth, with fine radiating grooves in the larger specimens, and also sometimes with concentric striæ. Epidermis thin, shining, yellowish brown. Beaks but little prominent; dorsal edge of the right valve overlapping the ligament and even more overlapping the edge of the left valve in front of the beaks. Hinge stout and broad, its inner edge very sinuous;

the internal ligament strongly divergent from the margin, its plate obliquely concavely truncate posteriorly; lateral teeth stout, obtuse. Palial sinus large, broadly rounded, reaching about the middle, its surface finely striated and iridescent. The color of the interior is usually a rich pink or deep flesh-color, lighter about the hinge; sometimes yellowish or bright orange; externally generally orange-yellow, with the umboes bright orange-yellow. One large specimen is pale yellow, with bright lemon yellow umboes; the inside yellowish white with the palial sinus and broad concentric bands pinkish.

Length,	3·15	inches.	2·55	2·35	1·44
Height,	2·65	"	2·20	2·05	1·16
Breadth,	1·40	"	1·12	·90	·52
Apex to anterior end,	2·10	"	1·86	1·60	1·00
Plication to posterior end,	·80	"	·60	·50	·32
Palial sinus from edge,	1·85	"	1·50	1·38	·85
Breadth of do.,	·87	"	·74	·62	·32

Near La Paz,—Capt. J. Pedersen. Six fresh specimens, the valves mostly together. Obtained by pearl divers.

This fine species is allied to *S. rosea* and *S. Jovis*. The latter, as figured by Reeve (Icon., vol. viii, Pl. v, 34), is similar in form and somewhat in color, but the lamellæ are closer, and the plication is nearer the posterior edge. The hinge and palial sinus are not described, and the locality is unknown.

S. rosea (Sowerby, 1832) was described from a single valve found at Tumbez, Peru. It is more orbicular and the lamellæ are much closer.

Semele formosa.

Amphidesma formosum Sowerby, Proc. of the Committee of Science and Correspondence of the Zoöl. Soc of London, Part II, 1832, p. 199; Reeve, Icon., viii, Pl. iv, fig. 27.

Semele formosa Adams, Genera, ii, p. 411.

Of this lovely species two fresh specimens with the valves together and two fresh odd valves were obtained with the preceding.

The form is much like that of *S. Junonia*, but the anterior dorsal edge is not concave, does not overlap, and the beaks are, therefore, even less prominent. The sides are covered with close, more or less irregular, often slightly oblique, concentric, rounded ribs, which are often furcate, especially at the posterior fold, separated by intervals of about their own width, and become very fine and close toward the apex, and often interrupted and nodulose on the umboes and anteriorly; beyond the strong posterior plication they are stouter, irregularly bent up and crowded, toward the apex rugose. Hinge less stout than in the preceding, the internal ligament more parallel and nearer to the margin, its plate not truncately terminated. Palial sinus large, broadly rounded, iridescently striated.

The color is varied with white, light lemon-yellow, rosy, brown, and purple; these colors being arranged partly in numerous rays, partly in spots and patches. Usually there are many alternating narrow rays of white and rosy, the other colors being more irregularly distributed, but in one specimen there are also regular rays of yellow on one valve. Inside the larger specimens are pinkish white, the middle and umbonal regions bright yellow, the ligament plate deep purple; but smaller specimens are mottled with purplish red and yellow.

The largest specimen is 2·75 inches long; 2·25 high; 1·05 broad; the palial sinus 1·62 long, from edge; ·85 wide.

Semele venusta (A. Adams, 1853) is perhaps only the young of this species. It was from West Columbia.

Callista pollicaris.

Carpenter, Ann. and Mag. Nat. Hist., vol. xiii, p. 312, 1865.
Dione prora var., Reeve, Conch. Icon., xiv, Pl. x, fig. 45, (*non* Conrad).

Several specimens of this rare and beautiful species were obtained, which show considerable variation, especially in color. Most of these are more transversely oval and less rounded below than the specimen figured by Reeve. The posterior end is always a little compressed and somewhat obliquely truncate. Ligamentary area long and narrow, slightly excavate, wrinkled. The sides are smooth and polished, finely concentrically striated; posteriorly and anteriorly obliquely corrugately wrinkled in most of the specimens, but in some, especially the smaller ones, the anterior wrinkles are obsolete, and sometimes also the posterior ones. Palial sinus large, broad and oval. Some specimens are white, with only a few small specks or waved lines of orange-brown, and a few stripes of the same color on the ligamentary area, the apex orange, upper part of lunule brown; more commonly the color is yellowish with concentric waved or zigzag streaks and spots of orange-brown, sometimes with imperfect radiating bands of the same color in addition; a large specimen is thus marked for about an inch from apex, beyond which it is white, faintly specked with brown. One large specimen is nearly white with many radiating bands of orange-brown on one valve; on the other diffused orange-brown, lighter above, crossed by many radiating darker brown bands. Another is darker chestnut-brown below, yellowish white toward the umboes, but destitute of bands and spots. Some of the smaller specimens have a purplish brown stain within, crossing the palial sinus; others are pure white.

Length,	2·10	inches.	2·08	1·75	·88
Height,	1·50	"	1·45	1·25	·66
Breadth,	1·00	"	1·00	·80	·44
Apex to posterior end,	1·75	"	1·68	1·35	·68
Palial sinus from edge,	1·15	"	1·10	·95	·46

Near La Paz,—Capt. J. Pedersen.

This species belongs to the subgenus, *Caryatis*, of Römer.

Tivela elegans, sp. nov.

The form is regular, transversely subelliptical, triangular above, nearly equilateral, slightly swollen at the umboes; the beaks but little prominent. Ligament short; lunule elongated, distinctly defined. Hinge narrow, not very strong. In the left valve the anterior tooth is prominent, about its own breadth from the beak; four principal cardinal teeth, nearly equally divergent, rather thin, the posterior one bilobed, the marginal lobe prolonged; in the right valve four principal, thin cardinal teeth, the middle ones most prominent, rugose, palial sinus large, broadly rounded, reaching nearly to the middle.

The La Paz specimens show great variation in color. Some are white with a few posterior oblique lines or spots of reddish brown; others are broadly indistinctly rayed and posteriorly wave-striped with lighter and darker grayish brown, leaving the umboes and two narrow radiating bands yellowish white. One is intricately and beautifully painted with rich reddish brown, in regular, concentric, waved and angulated bands, becoming zigzag posteriorly, with several median interrupted white rays, which differ on the two valves, and the posterior edge stained deep brown; this is deep purple within, except apical and anterior and posterior whitish spots. The lighter specimens are white within, except a spot of purplish about each muscular scar.

The San Salvador specimens present many other variations in color, but are mostly white, more or less profusely painted with chestnut-brown in various concentric, more or less waved and angulated bands, or in interrupted rays; in some the color is yellowish brown; in others the ground-color is reddish brown, with darker bands. The beaks are sometimes, but not usually, purplish; the interior generally white, with a purplish umbonal stain.

		T. elegans.			*T. Hindsii.*
Length,	1·02 inches.	·98	·82	·74	·65
Height,	·78 "	·80	·65	·58	·62
Breadth,	·48 "	·50	·42	·40	·50

La Paz,—Capt. J. Pedersen; Acajutla and Realejo,—F. H. Bradley.

This species varies somewhat in form, but is nearly always more traversely oval than *T. Hindsii*, of which we have typical specimens both from San Salvador and Zorritos, Peru, which agree exactly in form and color with Reeve's figures. *T. Hindsii* is short, triangular, with very swollen umboes, and the posterior end longest and a little produced, its sinus much smaller, and the ligament very short, the hinge stouter, with the lateral

teeth nearer the cardinal, and the latter more crowded and stouter. *T. radiata* is less regular in form than *T. elegans*, with much smaller sinus and broader and stouter hinge, a much longer ligament, sharper lateral tooth, and more numerous and more divergent cardinal teeth, the posterior ones being much more elongated.

The name, *Trigona* (Meg., 1811), is not only *later* than *Tivela* (Link, 1807), but was previously used among Hyemenoptera (Jur. 1807). It has also been used in Crustacea (Latr., 1817).

Venus isocardia, sp. nov.

A large, rounded, thick, and swollen species, cordate in front, with a broad deeply excavated lunule; with the sculpture entirely concentric,—the stout, elevated, rather close, slightly recurved and flattened ribs separated by deep interstices in which there are several very thin, crowded, slightly elevated lamellæ.

Umboes prominent, swollen, the beaks much recurved, not marginal; dorsal outline convex, broadly rounded and a little produced posteriorly; evenly rounded ventrally; anterior end short, deeply indented by the very broad and sunken lunule, which is smoothish and surrounded by a distinct groove, broadly cordate, extending between the beaks. Ligamentary area narrow, smooth on the left valve, the concentric sculpture extending over it on the right valve, which overlaps beyond the ligament. Muscular scars and palial line strongly marked, the sinus of moderate length, tapering to an obtuse point, about as deep as the width of the posterior muscular scar. Hinge stout, the anterior tooth in the right valve elevated and stout; central much larger, slightly bilobed; posterior one much elongated, and strong. In the left valve there is a small, conical, tubercular, anterior tooth; first cardinal elevated, stout triangular; followed by a stout strongly bilobed one; posterior one confluent with the ligament plate, long and curved, less elevated.

Exteriorly more or less stained and blotched with brownish; interiorly tinged with light orange near the umboes.

Length 3·25 inches; height 3·30; breadth 2·50; breadth of lunule ·68; length of palial sinus ·60.

Near La Paz,—Capt. J. Pedersen. Two fresh specimens.

This massive species is allied to *V. rugosa* of the West Indies, which it resembles in form and sculpture, but it has a different and stronger hinge. The posterior tooth of the right valve, especially, is much larger and longer, extending beyond the middle of the ligament. In the left valve the posterior tooth is also much elongated and reaches beyond the middle of the ligament, but it is much less elevated than in *V. rugosa*, and less separated from the ligament plate, there being only a shallow groove between.

It belongs to the typical *Venus*, as restricted by Messrs. H. and A. Adams and most recent authors, but Römer has given the subgeneric name, *Ventricola*, to this group.

Chione tumens, sp. nov.

A stout, thick, often swollen, subtriangular, somewhat beaked species, with broad, swollen, rounded, concentric ridges or undulations, increasing in size from the beaks to the margin, with faint radiating sculpture on the upper side of the ridges. The dorsal outline is nearly straight, the ligament groove broad and deeply excavated, smoothish in both valves, with a short ligament; posteriorly slightly truncate; ventrally broadly rounded; anteriorly rounded and a little produced; the lunule broad-oval, deeply sunken, smoothish, or marked with slight radiating lines. Beaks a little recurved, marginal. The concentric ridges or swellings are 12 or 14 in number, those near the beaks quite small and close, but rapidly becoming broader and more elevated; so that the last three occupy an inch or more in breadth; their upper surface is somewhat flattened and marked by low, crowded, radiating ridges, which are obsolete, or nearly so, on their outer side. The hinge is stout, its inner edge sinuous; the small anterior tooth in the right valve is thin and but slightly elevated; the central one stout, triangular and elevated; in the left valve the anterior tooth is stout, somewhat triangular and acute, as much elevated as the central tooth, but not so stout. Palial sinus quite small. Color externally, whitish, yellowish, or light brownish, variously marked and blotched with dark brown, which is sometimes in large radiating bands or spots, intermixed with narrow angular lines; at other times the brown markings are so numerous and crowded as to nearly conceal the ground color; within whitish, or with a dark purple stain posteriorly.

Length,	1·60	inches.	1·48	inches.
Height,	1·55	"	1·35	"
Breadth,	1·20	"	1·10	"
Apex to posterior end,	1·45	"	1·25	"

La Paz,—Capt. J. Pedersen. Forty-two specimens, mostly odd valves.

This species is very distinct from all others in its form and peculiar broad swollen ridges. It slightly resembles *C. subimbricata*, especially in color, but in the latter the first ridges are lamellar and the later ones much smaller, more numerous, and less swollen, while the shell is less beaked, the umboes less swollen, and the anterior edge is much less recurved and shorter, but the posterior more pointed. The hinge in *C. tumens* is also much broader and stouter, with the inner edge much more sinuous and the teeth longer and stouter.

Chione succincta.

Venus succincta Val, in Humb. Rec. d'Orbs., vol. ii, Pl. 48, fig. 1, p. 219, 1833, (t. P. P. Carpenter).
V. leucodon Sowerby, Proc. Zoöl. Soc. Lond., p. 43, 1835.
V. Californiensis Broderip, op. cit., p. 43; Reeve, Icon., Pl. xi, fig. 35, (*non V. Californiana* Con.).
V. Nuttallii Conrad, Jour. Acad. Nat. Sci Phil., vii, p. 250, Pl. 19, fig. 16, 1837; Reeve, Icon., Pl. xiii, fig. 49, 1863.
Chione succincta Carpenter, Rep. Brit. Assoc., 1863, pp. 569 and 620.

A fine series of this species is contained in the collection, including about fifty fresh specimens with valves together, and over a hundred odd valves of all sizes. These show considerable variation and confirm the synonymy of Dr. Carpenter, as given above.

In this species the shell, when adult, is thick and heavy, generally white, or nearly so, externally and internally, except that there is usually a deep purple stain posteriorly within, and often two spots or short triangular radiating bands near the apex, which is often purple or brown at tip. The form is somewhat triangular ovate, with the umboes and beaks quite prominent and recurved. The lunule is sometimes brown, generally narrow and ribbed; the ligamentary area is excavate, smooth on the right valve, and often nearly so on the left, though more commonly the concentric ribs extend around upon it in the form of crowded, more or less prominent wrinkles or slight folds; it is generally tinged with light brown or purple, on the right valve sometimes striped transversely with deep brown.

The sculpture is quite variable in the prominence and distance between both the radiating and concentric ribs, especially the latter. Over the umboes the radiating ribs are strong, and either alternate with smaller ones, are arranged by twos or threes, or are nearly uniform for some distance; posteriorly they become obsolete or nearly so, and in large specimens they gradually fade out and disappear at 2 to 2·5 inches from the apex, where the concentric ribs generally begin to become stronger, crowded, and more recurved. The concentric ribs on the umbonal region are generally ·10 to ·15 of an inch distant, toward the apex closer, and toward the base closely crowded, though not always so. The hinge is very strong, the teeth large, and the palial sinus very small.

Some of the larger specimens give the following measurements:

Length,	2·85	inches	2·65	2·75	2·60
Height,	2·85	"	2·70	2·75	2·55
Breadth,	1·65	"	1·60	1·70	1·60

La Paz,—J. Pedersen. It appears to live buried in sand or mud with only the posterior end exposed, which is therefore more or less worn and discolored in large specimens.

Chione undatella.

Venus undatella Sowerby, Proc. Zoöl. Soc. Lond., iii, p. 22, 1835; Reeve, Icon., xiv, Pl. 16, fig. 68.
V. neglecta Gray, Voyage Blossom, p. 151, Pl. 41, fig. 8, 1839, (t. P. P. C.).
V. simillima Sowerby, Thes. Conch., xvi, p. 708; Reeve, Icon., fig. 44.
V. perdix Val., Voyage, sur la frégate la Vénus, Pl. 16, fig. 2, 1846.
V. subrostrata Reeve, Icon., xiv, fig. 54, 1863, (*non* Lam.).
(*?*) *V. bilineata* (*pars*) Reeve, Icon., Pl. 22, fig. 105 *a*.
Chione undatella Desh., Catal. Veneridæ of Brit. Mus., p. 141.

A large series of this variable species was obtained, which shows that several nominal species have been based on characters that have no constancy. In its most normal condition it is more swollen, less triangular above, with the anterior end less produced, and the beaks much less prominent than the preceding. The sculpture, though variable, is similar, but generally the concentric ribs are closer and more regular. The lunule and ligamentary area are similar, but the latter is perhaps generally rougher on the right valve or both. The hinge is scarcely different, though somewhat variable with age, but the posterior tooth is perhaps generally somewhat longer, and the inner edge of the hinge-plate a little more sinuous. The palial sinus, as in the preceding, is very small. The color is quite variable. It is rarely perfectly white; more commonly externally buff or light cream-yellow, with transverse, waved or zigzag irregular stripes and radiating, often interrupted bands and irregular patches and spots of brown, sometimes also of purplish. Sometimes the brown markings are very light and scarcely distinct, the general color being buff; sometimes the markings are all regularly deeply angulated or zigzag lines, except on the umboes, which are blotched with brown; the apex is often bright brown or purplish; the broad radiating bands are frequently three or four in number and very distinct; many are merely mottled and spotted. Internally there is generally at least a more or less extended posterior purple stain; frequently the whole interior is tinged with a rich reddish purple, deepest outside of the palial line, with the hinge teeth bright red or lilac; sometimes the interior is pure white. The lunule and ligamentary area are usually stained or spotted with brown, the latter often with regular transverse stripes on the left valve.

In the *var. simillima* the radiating ribs are much finer posteriorly, fimbriating the concentric lamellæ, but there is also some appearance of this in the typical form, and some specimens have this form of sculpture for an inch from the apex, beyond which it fades out and the lamellæ are smoothish, or but slightly wrinkled.

Length,	2·05	inches.	1·95	1·90	1·80
Height,	1·95	"	1·85	1·55	1 65
Breadth,	1·30	"	1·30	1·05	1·10

La Paz,—J. Pedersen. With the preceding.

This species is very closely allied to *C. succincta*, and although the ordinary adult specimens are quite different in form and color, there are specimens which are, to a considerable extent, intermediate. It is also nearly impossible to satisfactorily separate young specimens, half an inch in diameter or smaller.

Papyridea bullata Sw. *var. Californica*, nov.

In form and color like the ordinary West Indian specimens, but perhaps a little more elongated than the average Atlantic form. Sculpture also similar in all respects, except that the radiating ribs are more prominent in the middle and especially over the umboes. The hinge shows some differences. In both valves the anterior lateral tooth is less prominent, narrower, and smaller, and the ligament plate is more prolonged and not so squarely truncate, reaching to or beyond the center of the posterior lateral tooth. The color externally is generally yellowish-white variously mottled and spotted with purplish brown; internally white, more or less stained with purple; one specimen is mottled with orange externally, and stained within with the same color, like some of the West Indian. The largest specimen is 1·75 inches long and 1·38 high.

La Paz,—J. Pedersen. Ten specimens.

Cardita Cuvieri.

Broderip, Zoöl. Soc., Proc. of Comm. of Science, p. 55, 1832.
Cardita Michelini Val., Voy. Vénus, Pl. 22, fig. 5, 1846.
Actinobolus Cuvieri Adams, Genera Rec. Moll., ii, p. 487, 1858.

Four large specimens of this rare and interesting species were obtained. They vary but little in form, color, or sculpture. In all the beaks are strongly recurved, umboes very prominent, the posterior depression strongly marked, the ribs very stout, flattened, transversely nodose, with deep square-cut grooves between. The color is deep mahogany brown, varying in shade; within white.

Length,	2·50	inches.	2·10	2·15
Height,	2·45	"	2·20	2·15
Breadth,	2·25	"	1·80	1·65

La Paz,—J. Pedersen. From pearl divers.

Cardita crassa.

Gray, Voyage of the Blossom, p. 152, Pl. 42, fig. 4, 1839, (t. P. P. Carpenter).
Actinobolus crassus Adams, loc. cit., p. 487.

This species appears to be more common than the last. It is more pointed, with the beaks less recurved; the posterior depression less marked; the ribs fewer, less prominent, low and rounded, with the interspaces, broad, shallow, concave, concentrically wrinkled. Color deep reddish brown; sometimes with

triangular lateral, or posterior transverse spots of yellow, the beaks white.

Length,	1·90	inches.	1·95	·65
Height,	2·20	"	2·10	·67
Breadth,	1·05	"	1·50	·50

La Paz, with last,—J. Pedersen.

Loripes edentuloides, sp. nov.

Closely allied to *L. edentula* of the West Indies and Gulf of Mexico.

It is subglobose, and much more swollen than *L. edentula*. The apex is more prominent and curved, and the lunular region more deeply excavated. The ligament is shorter and its supporting plate is not so stout, and its inner edge but little elevated above the ligament groove.

Length 1·65; height 1·50; breadth 1·10.

La Paz,—J. Pedersen. One specimen.

This is of special interest as another Gulf of California shell closely allied to a characteristic West Indian species. A large series of specimens might, perhaps, connect the two forms, but at present it seems necessary to keep them separate.

Xenophora robusta, sp. nov.

Shell large, elevated, regularly conical. Whorls seven or more, overlapping, bearing large pebbles and fragments of shells and corals intermingled, exposed surfaces roughly corrugately wrinkled, much crowded. Base broad, concave, densely and finely corrugated, spirally rudely costate by the lines of growth; yellowish brown. Aperture large, the inner lip and columella with a thick, lustrous, deep brown callus, which extends into the shell. Umbilicus closed by the reflexed inner lip.

Height,	2·35	inches.	1·70
Breadth,	2·75	"	2·20
Length of last whorl,	·85	"	·80

Near La Paz,—J. Pedersen. Two fresh specimens.

One of the specimens bears some large fragments of a shell that appears to be *Chione undatella*, the sculpture and color being preserved.

This genus appears to have been previously unknown on the west coast.

Enæta Pedersenii, sp. nov.

Shell small, rather slender, elongated; the spine regularly conical, acute, about two thirds the length of the body whorl; each whorl much flattened below the suture and encircled by a row of rounded tubercles; the body whorl with low, rounded, longitudinal costæ below the tubercles. Whole surface finely longitudinally sulcated or striated, on the upper whorls also transversely striated. Aperture narrow, contracted above, the

outer lip much thickened, the edge subreflexed, bearing at about the upper third a stout tubercle, below which it is crenulately toothed within; contracted at base by another small tubercle. One specimen, probably immature, lacks the tubercles and crenulations; columella with about seven plaits, the four lowest largest. Siphon narrow, a little prolonged and recurved, with acute edges. Color fulvous brown, specked with bluish white, with an interrupted band, or spots, of deep brown below the suture, a pale band over the tubercles and another, bordered with brown, below the middle of the body whorl. Length 1 inch; breadth ·50; length of body whorl ·63; length of aperture ·68; breadth ·12.

La Paz,—J. Pedersen. Five specimens.

This species is closely allied to the next, but is more slender, with the spire more acute, smaller tubercles and costæ, a more prolonged and recurved siphon, and more contracted aperture. The surface is not smooth and the color is lighter.

Lyria (*Enæta*) *Cumingii.*

Voluta Cumingii Brod., Zoöl. Soc. Proc. of Comm. of Science, 1832, p. 33.
Lyria (*Enæta*) *Cumingii* Adams, Genera, p. 167, 1858.

Our specimens are rather stout and solid, with large swollen tubercles and costæ, and a smooth polished surface. The best specimen lacks the tubercle on the inside of the outer lip, which is somewhat flaring and much thickened. The siphonal notch is scarcely prolonged and not recurved. The color is dark and rich brown, mottled and spotted with light bluish and flesh-color, with submedian and tubercular interrupted paler bands on the last whorl and an interrupted band of deep brown spots below the suture on the spine; interior salmon-color.

Length 1·33; breadth ·75; length of body-whorl ·85; aperture ·23 broad; ·82 of an inch long.

La Paz,—J. Pedersen. Three specimens.

Among the other species of special interest are *Codakia tigerina* (large and abundant), *Lucina undata* Carpenter, *L. excavata* Carp., in several varieties, *Mactrella exoleta*, *Tellina Cumingii* (abundant and fine), *Raeta undulata* (numerous valves), *Cyathodonta plicata*, *Placunanomia Cumingii* (three large specimens), *Conella cedonuelli* (many varieties of color), *Conus* (like *textilis*), *Cypræa pulchra* Kiener (ten specimens), *Cypræa* (*Luponia*) *Sowerbyi* and *L. albuginosa* (both in considerable numbers), *Cassis tenuis* (finely colored), *Harpa crenata* (several varieties of color), *Cassidulus patulus*, etc., all from La Paz and vicinity.

Note to Contributions to Zoology, No. V.—In the last number of this Journal, page 99, the generic name, *Oreaster*, should be substituted for *Pentaceros*. This change was made in the proof, after obtaining the reference to *Pentaceros* in Cuv. and Val., but the correction was overlooked by the printer.

ART. XXVII.—*Notice of Dr. Gould's Report on the Trans-Atlantic Longitude.**

Dr. GOULD'S able Report on the trans-Atlantic longitude has at last been published. It is full three years, however, since the field work to which it relates was finished, and more than two, as we learn from a prefatory note, since the paper in its present form (except the last chapter) was ready for the press. Astronomers have waited for it until patience was well nigh exhausted. Yet, thankful now that it is at last within reach, they will scarcely trouble themselves to press the question, why, or by whom, it has been so long withheld, or why it is now published by the Smithsonian Institution, and not by the Coast Survey itself, under whose auspices the work was done. For ourselves, waiving these, and like queries, as probably admitting of satisfactory answers, or, at least, such as would free the author of the Report from responsibility for the unexplained delay, we turn rather to the more welcome task of examining the Report itself, and laying some of its points before the readers of this Journal.

The paper fills a hundred quarto pages of the Smithsonian Contributions, and is one of the most important yet published on telegraphic longitude. For not only was the undertaking to which it relates among the most difficult and delicate, as well as important, of its kind, but the party put upon it brought to their task nearly the sum total of all the experience and practical skill that had then been developed in this special field; their chief having for fifteen years had exclusive charge of the longitude operations of the United States Coast Survey, and his associates, likewise, a long training in the same service. The Report may be taken, therefore, as a good exemplification of the telegraphic method in one of its latest and most difficult applications, and at the same time, as but a sample of the vast store of similar material that has been accumulating under the same hand from the entire longitude work of the Survey—material which embraced, before the war, no less than twenty-four independent determinations in the Atlantic and Gulf States—and which, surely, ought not to be much longer lost to science.

The Telegraphic method, it is now well understood, is distinctively American, and has had its chief development in the work of our great national Survey. That Survey has, in fact, among its many important contributions to science, given to the world

* The Trans-Atlantic Longitude, as determined by the Coast Survey Expedition of 1866. A Report to the Superintendent of the U. S. Coast Survey. By Benjamin Apthorp Gould, late assistant. Washington City: published by the Smithsonian Institution, 1869. New York: D. Appleton & Co.

the best methods yet devised of determining both latitude and longitude—Talcott's for the one, and the Telegraphic for the other; the former, devised in 1834, giving us in a single night's work with the zenith telescope, or a transit instrument used as such, the latitude to a small fraction of a second, and the latter, the longitude, also, for the first time in the history of geodesy, with corresponding facility and precision—a facility and precision, taken together, wholly unattainable by other methods, and in the case of longitude especially, unapproachable even, particularly in extended operations.

It was not till some years after the telegraphic method had been well elaborated here, and in successful use, that it received much attention abroad; and even then, the modes of practice recommended as original, by even eminent astronomers, particularly in France, were only such as had been long employed in our Coast Survey, or superseded by better, and had been published to the world repeatedly, and through various channels.

Almost simultaneously with the invention of the telegraph must have occurred to astronomers the idea of using it in determining longitudes. It was natural enough, therefore, that Arago should, in 1837, as is said, have suggested such a use of it to Morse. But the first actual experiment, so far as we know, was made, on the Baltimore and Washington line, in 1844, by comparison of chronometers at the two termini. The experiment was conducted by Captain Wilkes.

The method had, before this, engaged the attention of Prof. Bache, and he, quick to discern its advantages, in November, 1845, ordered its use in the longitude work of the Coast Survey—then in charge of the eminent astronomer, S. C. Walker; who, the next year, made a successful trial of it on the line between Philadelphia and Washington. From 1848, on, it was the method employed systematically in all determinations between points in the United States. Mr. Walker tried both the method of clock-signals, used in the experiment between Baltimore and Washington, and also the superior one of star-signals, used in the Coast Survey practice, almost exclusively, from the first. Dr. Gould succeeded Mr. Walker in 1851; and in the widely extended operations of the next ten years, brought the method to a very high degree of efficiency, and, with his aids, acquired that thorough mastery of the subject, which so well fitted both him and them for the difficult task, the history and results of which are set before us in this Report.

Dr. Gould's paper contains twelve chapters: 1, Origin of the Coast Survey Expedition; 2, Previous determinations of the trans-Atlantic longitude; 3, History of the Expedition; 4, Observations at Valencia; 5, Observations at Newfoundland; 6, Observations at Calais; 7, Longitude-signals between Foilhom-

merum and Heart's Content; 8, Longitude-signals between Heart's Content and Calais; 9, Personal error in noting signals; 10, Personal equation in determining time; 11, Final result for longitude; 12, Transmission-time of the signals.

The expedition had for its object a more exact determination of American longitudes, as reckoned from a European zero, than had yet been made. It was important, for the purposes of the Coast Survey, and of astronomical science, that the trans-Atlantic longitude should correspond in precision with those determined telegraphically within our own borders. The previous determinations of that longitude whether by moon-culminations, by eclipses and occultations, or by chronometers, differed very widely from each other. The range of difference was no less than five or six seconds in time. We take for comparison, the longitude from Greenwich, of the Naval observatory at Washington. This depends mainly on that of Cambridge, and this again, in part, on that of New York, Philadelphia, and other places. Between these points the longitude has been measured telegraphically. That between Washington and Cambridge was found by Walker, in 1848–9, to be $23^m\ 41^s\cdot54$, and has never been re-determined; but the link between New York and Jersey City was determined only geodetically, and that between Jersey City and Washington by simple clock-comparisons instead of the better method of star-signals; while another geodetic link was that of $12^s\cdot44$, between the Naval observatory and the Seaton station in Washington, to which all the telegraphic longitudes of the Coast Survey are referred. On account of these circumstances, and the omission, besides, in these earlier determinations, of many of the refinements and precautions since introduced, it seems highly desirable, as Dr. Gould suggests, that the longitude between New York and Washington, which he regards as the only weak link in our whole chain of telegraphic longitudes, should be carefully re-determined. Walker's value, however, as here given, is presumed to be very near the truth. Using the above quantities, Dr. Gould finds for the determinations of the longitude of the Naval observatory from Greenwich, which have appeared best entitled to confidence in recent years, the following:—

1. *From Eclipses and Occultations.*—The value adopted in the volume of Observations for 1845 is $5^h\ 8^m\ 14^s\cdot64$. Peirce, in 1845, from occultations observed by Bond from 1839 to 1841, gave $5^h\ 8^m\ 13^s\cdot9$. Walker, from all available observations between 1767 and 1842, obtained $5^h\ 8^m\ 14^s\cdot16$, a value subsequently reduced to $13^s\cdot85$, by change in the adopted longitude of Philadelphia, Cambridge, and Washington. A correction of the lunar parallax, deduced by Airy, Walker and others, from various observations, required a still further diminution of all

American longitudes; so that we have at present from eclipses and occultations:

Walker, corrected value from observations before 1843,	$5^h\ 8^m,\ 11^s{\cdot}14$
Peirce, from eclipse of 1851, July 28,	11·57
Peirce, from emersions of Pleiades, 1839, Sept. 26,	11·45
Peirce, " " " 1856–1861,	13·13

2. *From Moon Culminations:—*

			h.	m.	s.	
Walker,	from Cambridge obs'tions,	1843–45	5	8	10·01	
Loomis,	" Hudson "	1838–44			9·3	
Gilliss,	" Capitol Hill "	1838–42			10·04	
Walker,	" Washington "	1845			9·60	
Newcomb,	" " "	1846–60			11·6	±0·4
Newcomb,	" " "	1862–3			9·8	

Walker considered $9^s{\cdot}96$ as the most probable value from moon-culminations, and Newcomb assigned $11^s{\cdot}1$ as that indicated by the Washington observations from 1846 to 1863, inclusive.

3. *From chronometers transported between Boston and Liverpool.*

	h.	m.	s.	
Mean from 373 previous to 1849,	5	8	12·46	
Bond's discussion of 175, expedition of 1849,			11·14	
Walker's " " " "			12·00	
Bond's " " " "			12·20	±1·20
Bond's " of 52, 6 trips, expedition of 1855,			13·43	±0·19

The new telegraphic determination of the longitude between Liverpool and Greenwich adds $0^s{\cdot}06$ to all these values.

The discordance of the most elaborate and trustworthy results obtained by the old methods is thus seen to exceed four seconds. The value employed by the Coast Survey from 1852 to 1859 was $5^h\ 8^m\ 11^s{\cdot}2$; since 1859 it has been $5^h\ 8^m\ 11^s{\cdot}8$.

This great uncertainty of the trans-Atlantic longitude—from 30 to 60 times greater than that of our Coast Survey determinations—required that the earliest opportunity presented by the successful laying of an ocean cable should be seized for determining this longitude telegraphically, and with all possible precision. Measures were early taken to use, for this purpose, the cable of 1858, and, again, that of 1865; but, of course, in vain. In 1866, however, the cable of that year, and the recovered cable of the year before, afforded the desired opportunity. The expedition, organized under authority of the Coast Survey, was directed by Dr. Gould, and composed of officers of the survey, who were among the most skilled in longitude work. Messrs. Gould and Mosman went to Valencia, Ireland, Messrs. Dean and Goodfellow to Heart's Content, Newfoundland, and Messrs. Davidson and Chandler to Calais, Maine; for, the complete solu-

tion of the problem in hand, required the determination of three separate longitudes: 1, between Greenwich and Valencia; 2, between Valencia and Heart's Content, and 3, between Heart's Content and Calais, the easternmost station of the series connected by the telegraphic determinations of the Coast Survey. The first was accomplished by the ready co-operation of the Astronomer Royal. The second and third involved the principal labor, and presented the chief difficulties.

And these difficulties were by no means trifling. Wretched climate, defective land lines, unprecedented distance, with other untoward conditions, all conspired to render success by no means easy. Neither Valencia, nor Newfoundland, had, it would seem, any attractions for an astronomer. At Valencia, the observers were informed, on their arrival, early in October, that it had rained every day, without exception, for eight weeks. It was not until the 14th that any instrumental adjustments whatever, could be effected. During the seven weeks of their sojourn "there were but four days on which no rain fell, and there was but one really clear night during the period while the instruments were in position. The observations were, in general, made during the intervals of showers; and it was an event of frequent occurrence for the observers to be disturbed by a copious fall of rain while actually engaged in noting the transit of a star." The climate of Newfoundland appears to have been no better for astronomical work than that of Valencia. Messrs. Dean and Goodfellow reached Heart's Content on the 20th September, but saw neither sun, moon, nor stars until the 16th October, when they made their first imperfect adjustments of the transit and clock. In such circumstances, it is certainly most creditable to the skill and energy of the observers, that so many and excellent observations were obtained, as are discussed in this report.

The most formidable difficulty encountered, however, was the defective condition of the long land line of 1,100 miles between Newfoundland and Maine. On this line there were no less than four "repeaters," or double relay magnets, and two stations at which messages were re-written, without even an automatic "repeater," until these indispensable instruments were furnished for those stations by Mr. Davidson. But even with these provided, and with the most laborious precautions taken in other respects, all efforts at direct communication proved unavailing, day after day, and week after week. Mr. Davidson's health becoming impaired, his place at Calais was taken by Mr. Boutelle, one of the most experienced officers of the survey. Singularly enough, it was only a couple of hours before his arrival, on the 11th December, that, suddenly, the long-desired communication was found to be established. "A

sharp frost had thrown the otherwise defective line into a condition of admirable insulation, so that an interchange of clock signals was effected without difficulty." The signals afterward obtained over this line were, in the main, quite satisfactory, and sufficiently numerous to ensure a trustworthy result; still this third link in the chain of longitudes is undoubtedly its weakest part.

A further difficulty was presented by the unprecedented interval between the meridians; necessitating the use of simple clock-comparisons instead of star-signals, and preventing the interchange of observers for eliminating the effects of personal equation. Star-signals—i. e., signals transmitted at the instant a given star passes the several wires of the transit instrument, first at one station and then at the other, and registered at both —have these advantages over mere clock-signals—beats sent from each station and similarly registered—that they give results independent of the star's right ascension, which, cannot be said of the other; that, unlike the other, they are independent also of absolute time-determinations, though not of instrumental errors; and, finally, that they yield results affected only by the clock's rate, and not its error, in the interval of the star's passage between the two meridians. Where this interval is large, as in the case before us, the special advantage of star-signals mainly disappears; and even if it did not, they would require too protracted an occupation of the cable, and in the climate encountered, or indeed, in any climate, the chances would be great, with an interval of three hours, against the same star being observed at both stations.

With the superior catalogue of time-stars, however, which had been prepared, and with the careful experiments for personal equation which were made both before and after the expedition, there was good reason to believe that, even with the clock-method, necessarily used, no sensible, or at least, considerable error depending on the right ascensions would be introduced, nor any, also, arising from uneliminated personal equation. That this was true, in both cases, the discussion of these points in the report seems conclusively to show.

Still another serious obstacle in the way of accurate longitude determination was the absence of any means for the automatic registration of the signals received; inasmuch as the loss of time in noting the signals was, in the method employed, not only considerable, but quite uncertain. The most sensitive electro-magnet tried, could not be actuated unless by a charge of the cable too strong to allow the transmission of signals with sufficient rapidity. When the Valencia clock was breaking circuit during an eighth part of every second, a permanent deflection only was observed at Newfoundland.

The instrument actually employed for receiving signals was Sir W. Thomson's very ingenious reflecting galvanometer, the construction and performance of which are thus described. "A small mirror, to the back of which is attached a permanent magnet, the joint weight of the two being from five to six centigrams, is held, by means of a single fiber above and below, in the center of a coil of fine wire, which forms part of the galvanic circuit; and its position and sensitiveness are regulated by movable bar-magnets placed in the immediate vicinity. Upon the mirror is thrown a beam of light through a slit in front of a bright kerosene lamp, and the deflections of the needle are noted by the movements of the reflected beam, which is received upon a strip of white paper. The exquisite delicacy of this galvanometer, as well as the electrical excellence of the telegraph cables, may readily be appreciated after the beautiful experiment in which the electricians at Valencia and Newfoundland conversed with each other on a circuit not far from 700 myriameters (4,320 statute miles) in length, formed of the two cables joined at the ends, using a battery composed of a percussion gun-cap, a morsel of zinc, and a drop of acidulated water."

It is obvious that, with this instrument, there must be an appreciable loss of time in noting signals, due to inertia of needle, etc., which would be avoided, or more definitely measurable, with an automatic register. But no such register was available. Fortunately, this loss, as is shown in the chapter on "Personal error in noting signals," proved to be more constant and measurable than was anticipated, and, affects the final result only in a very slight and limited degree. A very delicate automatic receiving apparatus has since been suggested by Dr. Gould for recording the signal on the chronograph, by contact of the galvanometer needle, whenever slightly deflected, with wires placed close on each side of it, and properly connected with the battery.

The other instruments used were the regular apparatus of the telegraphic party of the Coast Survey; at each station, a 46-inch transit instrument, with reversing apparatus, and a reticule of five "tallies," of five spider lines each; a chronograph, (Bond's "spring governor," at Valencia and Heart's Content, and a "Kerrison's regulator" at Calais;) and a circuit-breaking clock. Upon all the chronographs one pen, which is constantly tracing a line upon a revolving cylinder, records the signals, both of the clock and of the observer, by offsets from this normal line.

At Valencia, observations were obtained on fifteen nights, on no one of which was the sky unclouded. "On only two of the five nights on which longitude signals were exchanged with Newfoundland, was it possible to obtain observations after

the exchange, and this was possible, too, on only one of the three nights, when signals were successfully exchanged with Greenwich. Fifty-three complete transits were observed over all the threads; on and after November 5th, by Mr. Mosman alone; on the 25th and 28th October, by Dr. Gould; at other times by both. The clock corrections, however, whenever possible, were deduced from Mr. Mosman's observations; when otherwise, a constant correction of —0^s·08 was applied to Dr. Gould's. For both clock correction and azimuth, the conditional equations were solved by the method of least squares, a method introduced into this branch of the coast survey work by Dr. Gould, and an important means of giving precision to the telegraphic longitudes. We are indebted, indeed, to this eminent astronomer for the particular notation and methods of observation and reduction, which have been employed in the longitude work of the coast survey since it came under his charge, and which are described in the C. S. Report for 1856. The transit observations are given in full, with their reductions for the groups immediately preceding and following the longitude-signals, and with the normal equations and resultant values for each group.

A glance at these observations reveals at once, in the small residuals, both the accuracy of the star-places and the skill of the observers. For, necessarily, different sets of fundamental stars for clock and instrumental corrections were employed at the two stations, owing to their distance, and also at the same station on different nights, owing to the various hours at which the signals could be exchanged. Considering all the unfavorable circumstances, the degree of precision attainded is certainly remarkable. This must be attributed, in great part at least, to the extreme accuracy of Dr. Gould's own carefully elaborated catalogue of fundamental stars, prepared in 1862, for the use of the longitude parties of the Coast Survey, and in its second edition, furnishing still more precise places, especially for circumpolar stars.

The observations at Heart's Content, and at Calais, for time and instrumental corrections, were made, as at Valencia, in very unfavorable circumstances, yet, similarly, exhibit remarkable accordance. Fortunately, at the former place excellent series of transits were obtained, both before and after every exchange of longitude signals, whether with Valencia or with Calais. At the latter place, however, the clock gave serious trouble as well as the weather; yet the observations, though not as good as could be wished, proved to be much more accordant than might have been expected in the circumstances, and give, it appears, a small probable error of the final result.

Longitude signals were successfully transmitted between

Foilhommerum and Heart's Content on but five dates; October 25th and 28th, and November 5th, 6th, and 9th. The method of giving and receiving these signals is thus described in the Report. We quote at length, that a clear understanding may be obtained of that portion of the operations on which the precision of the result chiefly depends.

"Three series, of two sets each, were exchanged on every occasion; each set consisting of ten signals alternately positive and negative, at intervals of about five seconds, except that the fifth and eighth were preceded by pauses of ten seconds, which was also the interval between the two sets. The purpose of this arrangement was to discover whether the velocity of transmission was perceptibly affected by a longer time being allowed for the cable to recover its electrical equilibrium, and also to facilitate the identification of the individual signals. Some slight convenience in the practical details also arose from the circumstance that each set occupied one minute, and that each series consisted of ten positive and ten negative signals. Those signals were considered positive by which the platinum was put in connection with the cable and the zincode with the ground.

In receiving the signals, the observer (Mr. Dean at Newfoundland, and myself at Valencia) watched the deflections of the light-spot, while his thumb rested on the button of a delicately adjusted break-circuit key, which was pressed at the instant in which the deflection was perceived. This instant was thus recorded upon the chronograph, after a certain amount of delay, which we will call the personal error of noting, and which depended upon a considerable number of influences to be discussed hereafter. The keys by which the signals were transmitted were made by the American Telegraph Company, under the supervision of Mr. Dean, and are constructed according to the arrangement devised by Prof. Thomson for the Atlantic Telegraph, in such a manner that pressure upon one button produces a positive, and upon the other a negative signal, while no current flows at other times. To this arrangement an additional contrivance was applied by which the local circuit to the chronograph passed through the same key, and was interrupted by pressure upon either button, so that every signal transmitted through the cable was recorded upon the chronograph at the station whence it was sent.

It is thus manifest that the times of sending the signals were accurately recorded, while the times of receiving signals were recorded after an interval of time dependent on the personal error of noting, and inseparable from the time of transmission through the cable, except by some independent means of measurement. If this interval were the same for both observers, it would be eliminated entirely from the longitude and merged

with the time of transmission. Otherwise it would effect the resultant longitude by one-half the difference between the personal errors of noting for the two observers. Happily it proved to be very nearly the same for Mr. Dean and myself, and also measurable; so that it has been possible to eliminate its influence from the measure of velocity, as well as from the longitude."—*Rep.*, p. 54.

The relations of the several quantities derived from the observations, and entering into the final results, are expressed in the following equations: in which T and T' denote the clock times at Valencia and Newfoundland, respectively, Δt and $\Delta t'$ the clock errors, x the transmission time of the signals, and λ the longitude; these quantities being also distinguished by a subscript $_1$ and $_2$ for Valencia and Newfoundland signals respectively. Including in x the personal error of noting signals, the signals given and recorded at Valencia at the time T_1 will be registered upon the Newfoundland record at $T_1' = T_1 + \Delta t_1 - \Delta t_1' - \lambda + x_1$ and the signals given and recorded at Newfoundland at T_2 will be registered upon the Valencia record at $T_2 = T_2' + \Delta t_2' - \Delta t_2 + \lambda + x_2$. Thus the comparison of the records of Valencia signals, at the two stations gives $T_1 - T_1' = \Delta t_1' - \Delta t_1 + \lambda - x_1$, while the comparison of the records of Newfoundland signals gives

$$T_2 - T_2' = \Delta t_2' - \Delta t_2 + \lambda + x_2,$$

and consequently

$$2\lambda = (T_2 - T_2') + (T_1 - T_1') + (\Delta t_2 - \Delta t_2') + (\Delta t_1 - \Delta t_1') + (x_1 - x_2)$$

$$x_1 + x_2 = (T_2 - T_2') - (T_1 - T_1') + (\Delta t_2 - \Delta t_2') - (\Delta t_1 - \Delta t_1')$$

If we assume the personal error of noting to be the same for the two observers, and the signals to travel with equal velocity in the two directions, the term $x_1 - x_2$ will disappear from the first equation, while the second will give a measure of the sum of the transmission-times and the personal errors of noting.

The several quantities above indicated are given in detail in the Report for the different series of signals, and exhibit excellent accordance in the results. There appears to have been no difference of clock rates to affect the deduced value of x, nor of velocity for eastern and western signals to require a correction of λ depending on the clocks.

The resultant values for the longitude, subject, however, to a correction for personal equation in determining time, are as follows:—

1866, October	25,	$2^h\ 51^m$	$56^s{\cdot}477$
	28,		56·487
November	5,		56·455
	6,		56·481
	9,		56·460

The mean interval between the moments of giving the signals and of their record upon the chronograph sheet is similarly found to have been

October	25,	0ˢ·62	± 0ˢ·008
	28,	0·64	·010
November	5,	0·59	·004
	6,	0·55	·007
	9,	0·54	·005

in which the quantities appended are the probable errors of the respective determinations as deduced from the total results of the several sets, there being six sets for each determination except that of November 6th.

Between Heart's Content and Calais the clock signals were much less satisfactory; being obtained only on four nights, on only two of which the clock errors could be determined either immediately before, or soon after, the exchange, and on one of these two there was special trouble from the clock. By some misunderstanding, also, the signals were not exchanged strictly according to programme, and thus a further source of uncertainty was introduced from the partial confusion occasioned in the record, and the greater difficulty of eliminating personal equation. The resulting longitude and time of transmission exhibit, however, better accordance than was to have been expected, and are as follows (subject to a correction for personal equation):

1866.		λ.	*x*.
December 11,	0ʰ 56ᵐ	37ˢ·89	0ˢ·24
12,		37·53	0·31
14,		37·84	0·27
16,		37·78	0·28

From the description of the mode of receiving signals, quoted on page 236, it will be seen that there is introduced, in all the observations, a special error due to the different methods employed at the two stations of recording a given signal. This is called in the report, "the personal error of noting." It is the interval between the arrival of the signal at the galvanometer and its record on the chronograph; for it will be remembered that the signal sent through the cable does not pass at once, automatically, to the chronograph, as at the transmitting station, but reaches it only through the mediation of an observer, who, after noticing the deflection of the light-spot from the galvanometer, sends a second telegraphic signal to his own chronograph. The whole interval, *x*, therefore, which elapses between the giving of a signal at one station and its chronographic record at the other, is made up of several parts.

These parts, as given in the Report, consist of the time requisite,—

1. For the signal to arrive at the other station.
2. For the galvanometer needle to move through a perceptible arc.
3. For the observer to notice the motion and tap his break-circuit key.
4. For this observation-signal to be recorded upon the chronograph.

Of these the second and third constitute the "error of noting," which is, therefore, partly instrumental and partly personal; the one due to the inertia of the galvanometer-magnet, the other being the "transmission-time" along the nerves from eye to brain, through brain, and thence to finger-tips; consisting, therefore, of three distinct intervals, viz.: 1, between phenomenon and perception; 2, between perception and volition; 3, between volition and giving signal. The sum of these three intervals, according to the experiments made by Dr. Gould, could hardly exceed, for good observers, $0^s{\cdot}3$; which would give for velocity of transmission through nerves about 13 feet, unless, indeed, some considerable time is occupied in the act of volition after perception, as seems probable from the experiments of de Jaager and Hirsch. Helmholtz made the velocity of nerve-sensation in the frog (dead), by different experiments, 87 and 89 feet per second. Dr. Schelske found that velocity in the nerves of common sensation and along the spinal cord in living men, to be about 97 feet. Others make the velocity not more than half as great.

With respect to the four intervals which make up the quantity x, it is remarked that, if equal at the two stations, they become wholly eliminated in the resultant longitude; if unequal, the longitude must be increased by one half the excess of their sums for westward signals. In either case, the operations for longitude give only their total sum at the two stations. The chronographs at both stations being similar, it might be presumed that the time lost by both in making the record after the key is tapped would be the same; and repeated examinations showed that this was sensibly the case. It therefore becomes eliminated in the resultant longitude; as does also the transmission-time through the cable, if sensibly the same in both directions; as Dr. Gould shows that it is.

The method employed for determining the "error of noting" was alike ingenious and successful. It was by carefully observing a series of signals similar to those exchanged for longitude, and so arranged that both the original signal and the observation of the consequent deflection were recorded on the same chronograph. The similarity requisite in respect to

intensity of current, was secured by an ingenious adjustment of battery force to both galvanometer and chronograph, by means of a divided circuit, the branch of it through the galvanometer being a German silver wire so fine as to give an intensity, as compared with that in the other branch, of 1 to 100; the requisite reduction. Other equally skillful devices secured similarity and freedom from error in other respects.

These experiments showed the range of variation of this error of noting for different individuals to be very small; the mean error for Dr. Gould at Valencia being $0^s{\cdot}271$, and for Mr. Dean at Newfoundland, $0^s{\cdot}335$; the difference being due to the galvanometer, probably, rather than the observer. The sum of the two $0^s{\cdot}606$, is the quantity to be deducted from the value of $x_1 + x_2$ to obtain the true time of transmission, and half their difference, or $0^s{\cdot}032$, that to be deducted from the longitude after all other corrections are applied.

In conducting these experiments a very curious source of error was detected, in the effect of hearing the click of the key, upon observations supposed to depend only on seeing the deflection of the needle. This is a point of so much importance to observers, that we quote the suggestion of the Report, "that a very marked effect upon the observation of transits of stars is likely to be produced when the chronograph is in the same apartment, so that the regular beats of the magnet are audible. When the intervals between the transit-threads are approximately multiples of half a second, the tendency is very great so to tap upon the observing key as to produce a rhythmical beat in the armature; and when the interval differs from the multiple of a second, the occurrence of that magnet-beat which records an even second often precipitates the tap of the observer, whose nerves are in keen tension awaiting the instant of bisection. Only a strong effort of will can obviate these perturbing influences—which are akin to those exhibited in the measurements just described."

This curious effect seems to show that eye and ear do not report to the brain with the same promptness, and that, when addressed simultaneously, the mind cannot recognize which makes the report, but takes that of one or the other, or both together, indiscriminately, the range of uncertainty being equal to the difference in promptness of the two senses. Possibly part of the effect may be due to a definite lapse of time between the occurrence of the audible and the visible signal; which, however, should give a more constant effect.

Want of space compels us to pass the interesting chapter on "Personal equation in determining time," with simply the remark that the ordinary methods of measuring that equation being inapplicable, by reason of the distance and other circumstances,

comparisons were made between the observers for this purpose as soon as practicable after their return; and the values deduced, though in many respects quite unsatisfactory, were adopted as the best approximation that could be obtained for the different observers. They are these:

Gould—Mosman	$=+0^s\cdot02$
Dean—Mosman	$=+\ 0\cdot11$
Goodfellow—Dean	$=+\ 0\cdot14$
Boutelle—Goodfellow	$=-\ 0\cdot14$
Boutelle—Chandler	$=-\ 0\cdot04$

A special arrangement, by which it was intended to entirely eliminate personal equation at Heart's Content, unfortunately failed through some misapprehension of the observers. The fact, however, that they had been in the practice of observing together for many years and had always found the equation between them to vary between very narrow limits, on the two sides of zero, rendered the failure of little practical consequence.

We hasten to give briefly the final results for longitude.

Between Foilhommerum and Heart's Content we have for the several dates, after corrections applied:—

1866, Oct.	25,	$2^h\ 51^m\ 56^s\cdot457$
	28,	$\cdot468$
Nov.	5,	$\cdot455$
	6,	$\cdot481$
	9,	$\cdot460$

The final longitude deduced, after correction for personal equation in determining time, Dean—Mosman$=+0^s\cdot11$, and in noting signals, Dean—Gould$=+0^s\cdot03$, becomes

$$\lambda=2^h\ 51^m\ 56^s\cdot54$$

Between Heart's Content and Calais, the results, similarly corrected, are for the several dates:—

Dec.	11,	$0^h\ 55^m\ 37^s\cdot93$
	12,	$[37\cdot53]$
	14,	$37\cdot84$
	16,	$37\cdot82$

And the final result, corrected by $-0^s\cdot14$ for personal equation between Boutelle and Goodfellow, and omitting Dec. 12, is—

$$\lambda=0^h\ 55^m\ 37^s\cdot72$$

Between Greenwich and Foilhommerum, the longitude was obtained by satisfactory signals on two nights, and compared with two previous determinations by Mr. Airy for other points at Valencia, by short geodetic connections. The two nights exchanges gave

		λ.	α.
1866, Nov. 5,	0h 41m	33s·305	0s·115
13,		33·280	0·110
Mean,	0 41	33·29	

This differs by —0s·10 from that adopted by Mr. Airy as deduced from the great chronometric expedition of 1844, and the telegraphic determination of 1862.

The combination of the three longitudes thus determined, gives—

Greenwich—Foilhommerum,	0h	41m	33s·29
Foilhommerum—Heart's Content,	2	51	56·54
Heart's Content—Calais,	0	55	37·72
Greenwich—Calais,	4	29	7·55

"The Valencia observations having been made by, or referred to, Mr. Mosman throughout the whole period, his personal equation is eliminated; the equation between Messrs. Goodfellow and Dean, always small, may be regarded as trustworthy, and by a happy coincidence the personal equations of Mr. Boutelle on the west, and of Mr. Mosman on the east, seem to be almost identical, so that even a total disregard of this quantity would have resulted very nearly in its perfect elimination, the oceanic arc being diminished and the land arc increased, each by about 0s·14."

The only probable influence of personal equation in the entire longitude-measurement, comprising, as it does, three-sixteenths of the whole circumference, lies in the difference between the observations of Messrs. Dunkin and Boutelle.

The longitude of Calais, as heretofore telegraphically determined, is as follows:—

Calais—Bangor,	0h	6m	0s·31
Bangor—Cambridge,	0	9	22·99
Cambridge—New York,	0	11	26·07
New York—Washington,	0	12	15·47
Calais—Washington,	0	39	4·84

whence we have

Greenwich—Washington, 5h 8m 12s·39

The Seaton Station being 12s·44, and the dome of the Capitol 10s·17, east of the Naval Observatory, to the center of the dome of which the preceding value refers, we have as their longitudes from Greenwich—

Seaton Station,	5h	7m	59s·95
Capitol,	5	8	2·22

From the facts, as exhibited in this report, there would seem to be every reason to believe that this result is within a very small fraction of a second of the exact longitude, and that the small probable error, whatever it may be, is mostly due to the weakest link in the whole chain—that between Newfoundland and Calais.

The indiscriminate mean of all the chronometer determinations, as given early in this article, using the numbers of chronometers as weights, is $5^h\ 8^m\ 12^s{\cdot}14$; leaving out Bond's first discussion of the 175, it is $5^h\ 8^m\ 12^s{\cdot}37$. The mean of Peirce's two from occultations of Pleiades, without regard to weight, is $5^h\ 8^m\ 12^s{\cdot}29$.

We regret that we have not room for even a brief abstract of the valuable closing chapter on the transmission-time of signals, but are compelled to dismiss it with barely stating the general result and some conclusions with respect to a few points, as derived from the experiments.

The transmission-time by cable, after correction for personal error in noting signals ($0^s{\cdot}303$), was found to be for the several dates:—

1866, October	25,	$0^s{\cdot}314$	Cable of 1865, with earth and condenser.
	28,	·343	" " " " " "
November	5,	·280	Both cables, no earth.
	6,	·248	" " " "
	9,	0·240	" " " "

The battery-strength on these nights was as follows:—

October	25,	10	cells at	Valencia,	10	cells at	Newfoundland.
	28,	10	" "	"	10	" "	"
November	5,	3	" "	"	3	" "	"
	6,	3	" "	"	10	" "	"
	9,	4	" "	"	10	" "	"

From these results the inferences seem warrantable, 1st, that the velocity of transmission is greater when the circuit is direct and consists of a good metallic conductor exclusively, than when the signals are given by induction, although the earth may be at the other electrode; and 2d, that an increase of intensity in the electromotive force is attended by an increase in the velocity of propagation of the signal.

From the observations for longitude, and from other experiments made with special reference to particular points, the following general conclusions were reached.

"It appears manifest that not an electrical charge or discharge, but simply an electrical disturbance, is requisite for transmitting a signal; that an inductive impulse, sufficient to deflect the galvanometers employed, was transmitted through one cable,

having at each end a condenser with 10 cells, in somewhat less than the third of a second, five seconds after the transmission of an impulse of the opposite sort; that with a circuit formed by the two cables, a smaller electromotive force sufficed to transmit the signals with yet greater rapidity; that the signals traveled more rapidly through a cable which had not recovered its electrical equilibrium after a current of the opposite character; and that the speed of the signals is modified by the earth-connections, more readily than by changes in the battery-power. And the very marked differences, found in the rates of transmission, between signals given by completing an interrupted circuit and those given by interrupting a closed circuit, may perhaps lead to investigations which will afford an explanation."

C. S. LYMAN.

ART. XXVIII.—*Meteors of November*, 1869; compiled by H. A. NEWTON.

THE cloudy weather in most parts of the United States and Europe prevented continuous observations of the November meteors, at the time of their return in 1869, by nearly all those who were watching for them. The observers, in the few stations where the skies were clear, furnish, however, ample testimony to the appearance of unusual numbers on the morning of Nov. 14th. The display, moreover, like that of 1868, continued for several hours. I give below the particulars of the observations at various places.

1. *At New Haven.*—Two members of the Junior Class, Messrs. C. B. Dudley and R. P. Maynard, saw, through openings in the clouds, six meteors, between 4^h and 5^h on the morning of the 14th. Some of them had the peculiar trains belonging to the November meteors. On the next morning, Nov. 15th, the sky was nearly overcast, but between 3^h and 3^h 45^m, we saw eight meteors, four of them conformable. During the rest of the morning the sky was overcast, and even in this interval it was at no time more than one third clear.

2. A similar failure, nearly or quite complete, is reported by Prof. Eastman, at the U. S. Naval Observatory, Washington, by Mr. Marsh and Mr. Taylor, at Philadelphia, by Mr. Fuertes at Stamford, Conn., by Mr. Boerner, at Vevay, Ind., by Prof. Rockwood at Brunswick, Me., and by various others who were in readiness to make observations.

3. *At Pensacola, Florida.*—To the courtesy of Commodore Sands, Sup't. of the U. S. Naval Observatory, we are indebted for a letter of Commander Wm. Gibson, from Pensacola. He says that the night of the 13th–14th was exceedingly bright and

clear, and that the shooting stars were observed in extraordinary numbers, from $1^h\ 15^m$, A. M., until dawn, most numerously between 3^h and 4^h, A. M. It was difficult to give the average per minute. It varied from two or three to twenty or thirty, or more, the star-showers flashing and intermitting like the bursts and pauses of a gusty rain. In magnitude they varied from mere moving points of light, to those which were larger than Jupiter. One train remained visible at least 50 minutes, drifting slowly to the northward.

4. *Upon the Pacific Ocean.*—To the courtesy of the Secretary of the Smithsonian Institution, we are indebted for a letter of Mr. Alexander Evans of Elkton, Md.

On the morning of Nov. 14th, he was upon the Pacific Ocean, lat. 8° 30′ N., and long. 84° 30′ W. He watched from two till four o'clock, when the sky became overcast. Between these hours the sky was partly covered. The display was, he says, quite equal to that of 1868 which he observed throughout. He thought that the radiant point was not as last year, in the center of the sickle in Leo, but a little more to the eastward between the stars γ and γ. There were several nonconformable meteors whose radiant seemed to be the zenith.

5. *At Santa Barbara, California.*—To the courtesy of Prof. Peirce, Superintendent of the U. S. Coast Survey, we are indebted for the observations of Mr. Geo. Davidson, Assistant, and Mrs. E. Davidson at the Coast Survey station, at Santa Barbara (lat. 34° 24′, lon. $7^h\ 59^m$). Between $1^h\ 18^m$, A. M., and $3^h\ 43^m$ on the morning of Nov. 14th, they counted 556 meteors. The following table represents the number of meteors seen by the two observers *per minute*. They are taken from the diagram forwarded by Prof. Peirce.

1^h	23^m	2·2	meteors.	2^h	16^m	5·0	meteors.	2^h	46^m	3·0	meteors.	3^h 15^m 5·0 meteors.
	35	3·6	"		21	5·2	"		51	4·0	"	21 2·5 "
	47	4·8	"		25	5·0	"		55	6·0	"	25 2·0 "
	53	5·0	"		31	2·2	"	3	1	6·0	"	31 3·7 "
	59	3·8	"		35	2·2	"		5	3·0	"	35 3·2 "
2	9	4·8	"		41	6·6	"		11	2·0	"	41 4·0 "

Mr. Davidson says, "the night was beautifully clear, the moon being ten days old, and 4° south. I was called at $1^h\ 10^m$, A. M., up to which time 22 meteors had been seen. After $3^h\ 43^m$, A. M., watch was kept for any unusual display, but the numbers gradually diminished. Some of the meteors were very brilliant and left persistent trains. About half a dozen meteors were observed moving in directions toward the radiant.

"At $2^h\ 33^m$, A. M., I observed a brilliant meteor start from a point above, and a little to the left of the pointers; it left a persistent train and disappeared at a point about 9° or 10° above Polaris, and 6° to the right. The train was 5° in length;

gradually it took a wavy form; then curved until it formed two-thirds of an irregular circle, and was 3° in diameter and half a degree in width. I examined it with a good binocular, and found it not of uniform density, but having open spaces in it. It remained visible 8½ minutes, and in that time apparently moved in a line toward the radiant point in Leo, over a space of 8°."

The small number of meteors reported above as seen between $2^h\ 30^m$ and $2^h\ 40^m$ was due to Mr. Davidson's being engaged in watching the train of this meteor.

At $1^h\ 15^m$ Mr. S. R. Thockmorton, Jr., saw a meteor appear and disappear without apparent motion. It was about two degrees above and to the left of the bright star in the blade of the sickle.

6. *At Fredericton, N. B.*, (lat. 46° 3′, lon. 66′ 45′).—A watch was kept up by relays of students of the University of New Brunswick, throughout the night of Nov. 13th, 14th. They report the times and general directions of the individual meteors, with duration of flight, brilliancy, &c. The following table of the numbers seen in each 10 minutes of the night is compiled from their report.

Number of meteors seen at Fredericton, N. B. on the night of Nov. 13th, 14th.

Hour.	0m–10m	10m–20m	20m–30m	30m 40m	40m 50m	50m 60m	Total.
7— 8				1	1	1	3
8— 9	1	1	3	1	0	1	7
9—10	0	0	1	1	1	2	5
10—11	4	0	4	3	2	5	18
11—12	8	12	4	6	6	3	39
12— 1	10	6	4	5	8	26	59
1— 2	6	18	6	8	12	17	67
2— 3	11	10	26	32	37	20	136
3— 4	24	44	23	55	21	14	181
4— 5	22	30	28	35	34	18	167
5— 6	25	31	20	16	22	20	134
6— 7	7	30	4				14
				Total in 11 hours,			830

The observations were made by three parties, each watching for two successive hours. Messrs. Byers, Crozier, Stone, Connell and Williston watched from $7\frac{1}{2}^h$ to 9^h and from 1^h to 3^h.

A second party, consisting of Messrs. Vanwarts, Cliff, Wortman, Belyea, and Lawrence, watched from 9^h to 11^h and from 3^h to 5^h, and a third party consisting of Messrs. Willbur, Scovil, Chandler and Walker watched from 11^h to 1^h and from 5^h to $6\frac{1}{2}^h$. Only four persons were, however, observing at any one time.

7. *In England.*—The clouds prevented observations for most of the time in Great Britain. At Glasgow, Mr. A. S. Herschel

and Mr. Robert McClure had a tolerably clear sky from half past 4 till half past 5.

"Meteors of the brightest class of the November shower, having luminous streaks, were crossing the sky at the rate of about 40 in an hour, for one observer, corresponding to a rate of frequency of at least one hundred per hour, in all the sky. The apparent paths of thirty of these meteors were recorded upon a map, by their course among the stars, and the direction of their flight was from the usual radiant point in the constellation Leo. * * * *

"A clear view of the sky was again obtained towards eleven o'clock on Sunday night, when a single shooting star, passing from Gemini to Taurus, and leaving a faint streak, appeared to be the last visible representative of the November meteors. Although the sky continued clear, and an attentive watch was kept for nearly three hours afterwards, no other meteor could be seen. The purely negative character of this result adds a fresh proof to the evidence obtained in former years of the definite boundaries and narrow limits between which the stream of the November meteors is confined."

Observations at Greenwich and at most other places in England were not successful on the morning of the 14th.

At Culloden, Mr. A. Forbes counted upwards of 200 between the hours of 3^h and 7^h, A. M., the maximum of the shower appearing to be about 5 o'clock.

8. *In France*, the "Association Scientifique" organized a system of observations, at various stations near the Mediterranean, embracing even one or two in Italy. The results were to be reported and discussed at sessions to be held in the latter part of the month of November, at Marseilles and Bordeaux. We have not learned what success rewarded the zeal of the French observers.

9. *At Paris.*—Mr. Chapelas reports to the French Academy of Sciences, that notwithstanding unfavorable weather and moonlight, "observations conscientiously made, give us for the mean hourly number reduced to midnight and to clear sky, and corrected for the influence of the moon, for the night of Nov. 12th, 6·8 meteors; for the night of Nov. 13th, 24·8 meteors."

He says that the observations for the preceding nights gave steadily, a smaller hourly number than the mean for that period of the year, which is, according to him, 13·6.

Mr. Chapelas, as usual, does not say how many meteors he saw, nor how long he observed, nor how large a correction he applies for cloudiness, nor what for moonlight, nor what to reduce to midnight. We are not aware, even that he has published rules or constants for such reduction. His *observations* might perhaps have some value, if we knew what they were.

They could then be criticized, and compared with those of other observers. If found to have been carefully made they would be valuable to science. But as now given to the world, the observations of Mr. Coulvier-Gravier and Mr. Chapelas are inextricably mixed up with their deductions. The manifest errors of the latter taint the whole, and make it necessary to throw them all away. The French Academy of Sciences publishes his reports, and we respectfully call its attention to the matter.

10. *At Vienna.*—Prof. Weiss of the Observatory of Vienna, with three aids, determined 36 paths with the meteoroscope between 2^h and 6^h, A. M., of the 13th (Prof. Schmidt in *Heis Wochenschrift*, Dec. 8th). Some of them were from the Leo radiant. The total number visible was very moderate.

The next night was stormy, and for an interval of 10 minutes only at 4^h, A. M., could anything be seen. A few stars of Leo, Gemini and Auriga were then visible through openings in the clouds, and along with them, though principally seen through haze, were some meteor tracks, having trains and radiating from Leo. Prof. Schmidt estimated that the hourly number for one observer was about 50, reckoning only the brighter meteors, and considered the display not greatly different from that seen by him at Athens in 1863.

At Munster and elsewhere in northern Germany the sky appears to have been overcast.

11. *At Rome.*—The cloudy skies which covered northern Europe on the night of the 13th, 14th, also impaired the Italian observations. Padre Secchi reports a few, though incomplete, from Rome.

At $2^h\ 30^m$ A. M. the clouds broke away in the west and in five minutes 18 meteors were seen. At $2^h\ 35^m$ the sky was nearly clear except low in the northeast, and a regular count was begun.

From $2^h\ 35^m$ to $2^h\ 40^m$, 29 meteors were seen; from $2^h\ 40^m$ $2^h\ 48^m$, 41; from $2^h\ 48^m$ to $3^h\ 0^m$, 73; from $3^h\ 0^m$ to $3^h\ 15^m$ 40. At $3^h\ 18^m$ it became again overcast. The whole number in 40 minutes was 183, of which 5 were unconformable. He omits to state the number of observers. Padre Secchi concludes:

1st. That there was a real recurrence of the display.

2d. That it was but little different from the display last year, there having been then seen in the same interval about 200 meterors. The hour moreover was not that of the maximum.

3d. That the radiant point was within the bend of the sickle in Leo, and made with the stars ε and μ an equilateral triangle. But this determination was not very precise owing to the want of tracks near the radiant.

4th. That the greater part of the meteors passed to the north of the radiant.

It was further remarked that the trains were visible only a few seconds, and that there were none of the beautiful scrolls of smoke which were seen last year.

Madame Scarpellini gives in her *Corrispondenza Scientifica* accounts of observations at Rome by herself, (with negative results) and the following from Perugia and Civita Vecchia.

12. *At Civita Vecchia.*—Prof. Pinelli reports to Madame Scarpellini the following observations from Civita Vecchia.

Nov. 12th–13th. Between $10^h\ 30^m$, P. M., and 1^h, A. M., 4 meteors seen of 1st magn., 6 of 2d magn., and 8 of the third. Only a few clouds.

Nov. 13th–14th. Between $11^h\ 30^m$ and $2^h\ 35^m$, 54 meteors seen. Very cloudy and finally overcast.

Nov. 14th–15th. Up to $1^h\ 20^m$, A. M., only 16 meteors seen.

13. *At Perugia.*—On the morning of the 13th from 12^h to 6^h, A. M., Prof. Bellucci counted the following numbers in the several hours; viz., 26, 22, 26, 28, 24, and 17. In all 138 in six hours.

On the next night in successive hours from 6^h, P. M., till 4^h, A. M., he saw 3, 1, 0, 2, 1, 2, 0, 39, 190, 246. During the next half hour 71 were seen, making 555 in all. From $4^h\ 30^m$ it was overcast.

14. *At Velletri.*—Prof. D. Ignazio Galli, of the Municipal Observatory at Velletri, watched during the two nights of the 12th and 14th of November. (*Bull. Met. Rom.*)

On the first night, two observers, with a clear sky, in five hours, from $12^h\ 45^m$ till $5^h\ 45^m$, saw 71 meteors. The distribution through the five hours was as follows:

From $12^h\ 45^m$	to	$1^h\ 45^m$,	2	conf.,	9	unconf.
" $1^h\ 45^m$,	"	$2^h\ 45^m$,	5	"	7	"
" $2^h\ 45^m$,	"	$3^h\ 45^m$,	8	"	6	"
" $3^h\ 45^m$,	"	$4^h\ 45^m$,	7	"	7	"
" $4^h\ 45^m$,	"	$5^h\ 45^m$,	11	"	9	"

On the second night they were able to see only through openings in the clouds. There were three or four observers, enough to fully command the whole of the visible portions of the sky. The results were as follows:

Time.		Meteors seen. Conf.	Unconf.	Portion of sky visible.	Total computed for clear sky.
$1^h\ 0^m$,	$1^h\ 15^m$	50	1	0·2	255
1 15	1 30	48	1	0·2	245
2 0	2 15	41	6	0.4	117
2 15	2 30	31	7	0·3	126
2 30	2 45	43	4	0·4	117
2 45	3 0	62	8	0·5	140
3 0	3 15	17	4	0·2	105
Total in $1^h\ 45^m$,		292	31		

The meteors of this second morning were much finer than those of the preceding morning. The sporadic meteors of each night appeared to radiate from Auriga.

15. *From Moncalieri.*—Director F. Denza reports in *Les Mondes*, for four observers:

Night of the	12th	of Nov. from	14^h	to	17^h	145 meteors.
"	13th	"	9		17	720 "
"	14th	"	$14^h\ 10^m$		$17^h\ 10^m$	99 "

These numbers need to be increased, as their principal object was to determine the position of the tracks and the instant of appearance of the meteors.

On the night of the 13th, 14th, there were seen:

At Alexandria by	4	observers from	$9^h\ 45^m$	to	$16^h\ 45^m$,	168 meteors,
At Aosta,	1	"	$14^h\ 30^m$		18^h	189 "
At Varallo,	1	"	$13^h\ 25^m$		$16^h\ 25^m$,	121 "

Prof. Denza adds that "the meteoric shower of Nov. 1869, differs little from that of August, and in some places was even inferior to it."

16. *At Port Said, Egypt.*—In the *Monthly Notices* for Dec. are some observations of G. L. Tupman, Esq., at that place. On the mornings previous to that of the 13th, he detected some tendency to radiation from Leo. On that morning, of thirteen meteors, four were conformable.

On the morning of the 14th from $12^h\ 30^m$ to $13^h\ 15^m$ only two meteors were seen, neither conformable. There was a pretty large patch of clear sky overhead.

"The watch was resumed at $14^h\ 30^m$, the sky being then partly clear in patches, and continued until a quarter past 5, long before which the shower had entirely ceased. At $2^h\ 30^m$ it was at its height, most of the meteors being remarkably brilliant, and many of them tinted green. The greater part left bright streaks, which often remained visible a considerable time. The duration of the meteors or their 'time of flight' was considered to be less than half a second—too short a time to estimate even roughly.

"The following are the observations. Being unassisted, I stopped at every sixteenth to make the necessary entries.

"If the numbers in the table be reduced to an uniform interval of time and then multiplied by the cosecant of the altitude of the radiant, it will be seen that between $14^h\ 30^m$ and $16^h\ 24^m$ the numbers were nearly uniform, and slightly decreasing. The maximum, then, was either before or about $14^h\ 30^m$; but the *center* of the dense part must have been passed about 15 hours, as there was no sign of the shower at $13^h\ 15^m$.

Meteors observed at Port Said, Nov. 13th, Alexandria mean time.

From h	m	To h	m	No. of Meteors.	Elevation of the Radiant.
10	40·0	13	15·0	0	15
14	30·0	14	40·0	16	35
14	52·0	15	2·5	16	40
15	8·0	15	19·7	16	43
15	24·0	15	33·6	16	46
15	38·5	15	52·5	16	50
15	59·0	16	7·4	16	54
16	12·0	16	24·0	16	57
16	26·0	16	38·0	6*	60
16	40·0	16	52·0	7	63
16	54·0	17	14·0	4	67

Seven other meteors were observed, but they did not radiate from Leo.

From 11 orbits he determined $\alpha=151°·0$, $\delta=21°·5$, measured from the equinox of 1869. No single point satisfied all the paths that were observed.

The conclusions of Mr. Tupman respecting the closing of the shower are of course set aside by the observations in Italy and England by those of Fredericton and Santa Barbara.

17. The duration of the whole shower was at least twelve hours, and it appears to have been somewhat fitful in its intensity. Perhaps the apparent fitfulness may be due to the clouds, though we think that that is not the only reason.

Thus after the time named by Mr. Tupman we have an increasing display shown by Prof. Bellucci's numbers. At Culloden the report seems to carry this display on two hours longer. The numbers seen at Fredericton and Santa Barbara show a tolerably uniform continuance for several hours longer. There was little trace of the display on the next morning.

SCIENTIFIC INTELLIGENCE.

I. PHYSICS AND CHEMISTRY.

1. *On Ammonia-chromium bases.*—CLEVE has communicated to the Royal Swedish Academy of Sciences a memoir on the ammonia-chromium bases, which, though of not very recent date, has not, we believe, been noticed either in German or in English journals. The author sets out with the chlorid discovered by Fremy and investigated to some extent by himself in a previous memoir. To this he gives the formula, Cr_2Cl_3, $4NH_3$, $2HO$, and the name tetramin chrom-chlorid. It will be sufficient for our purpose to give

* During this observation it was more cloudy than before, but during the two following ones it was much clearer.

the formulas of the various compounds with a general account of their properties. The formulas of the salts described by Cléve belonging to the tetramin series are as follows:

Chlorid,	Cr_2Cl_3, $4NH_3$, 2HO.
Chlorplatinate,	Cr_2Cl_3, $4NH_3$, 2HO+$2PtCl_2$.
Chlorhydrargyrate,	Cr_2Cl_3, $4NH_3$, 2HO+6HgCl.
Chlorobromid,	Cr_2ClBr_2, $4NH_3$, 2HO.
Bromid,	Cr_2Br_3, $4NH_3$, 2HO.
Bromochlorid,	Cr_2BrCl_2, $4NH_3$, 2HO.
Chloro-iodid,	Cr_2ClI_2, $4NH_3$, 2HO.
Iodid,	Cr_2I_3, $4NH_3$, 2HO.
Chlorosulphate,	Cr_2ClO_2, $4NH_32SO_3$, 2HO.
Bromosulphate,	Cr_2BrO_2, $4NH_32SO_3$, 2HO.
Chlorochromate,	Cr_2ClO_2, $4NH_32CrO_3$, xHO.
Chloronitrate,	Cr_2ClO_2, $4NH_3$, 2NO5, 2HO.

All these salts are crystalline and easily soluble in water. They have a carmine red or garnet red color and their solutions are easily decomposed on heating, with separation of chromic oxyd and evolution of ammonia. The author calls attention to the very noteworthy fact that they all contain 2 atoms of water (in the old notation).

The second series of compounds described are the salts of heptamin-dichromium.

The formulas of the only observed members of this series are as follows:

Double nitrate,	$2(Cr_2O_3, 3NO_5)$, $7NH_3+NH_4O$, NO_5+9HO.
Oxalo-nitrate,	$2(Cr_2C_3, NO_5, (C_2O_3)_2)$, $7NH_3+6HO$.

The salts of the triamin series are as follows:

Oxalate,	Cr_2O_3, $3C_2O_3$, $3NH_3$, 3HO.
Double oxalate,	$2(Cr_2O_3, 3C_2O_3, 3NH_3)+NH_4O$, $2C_2O_3$, HO+3HO.

The salts of the heptamin and triamin series resemble those of the tetramin series so closely as not to require special description. The nitrate of the heptamin series is obtained by the action of nitrate of silver upon the chlorid of tetramin-chromium. The oxalate of the triamin series is obtained by the action of oxalic acid upon the same chlorid. Besides these three series the author describes the following salts, which may obviously be regarded as members of other and analogous groups.

Cr_2O_3, NO_5, $2NH_3+3HO$.
Cr_2O_3, C_2O_3, NH_3+8HO.
$2(C_2O_3)$, SO_3, $2NH_3+24HO$.

It is, however, very doubtful whether these three substances were

obtained in a state of purity, as they were all amorphous and could not be obtained crystallized.—*Kongliga Svenska Vetenskaps-Akademiens Handlingar, Ny Följd*, 1866, 7 vol., 2d half.

W. G.

[*Note.*—The compounds described by Cleve are of especial interest when considered from an atomistic point of view. The formulas of the triamin and tetramin series are of course to be doubled and we should then have for the three chlorids the empirical formulas

$6NH_3$, Cr_2Cl_6	Hexamin-chromium chlorid.
$7NH_3$, Cr_2Cl_6	Heptamin-chromium chlorid.
$8NH_3$, Cr_2Cl_6	Octamin-chromium chlorid.

Adopting Blomstrand's view of the constitution of the analogous platinum and cobalt compounds, these three bodies may be written as follows:

$$Cr^{VI}_2\begin{cases}-NH_3-Cl\\-NH_3-Cl\\-NH_3-Cl\\-NH_3-Cl\\-NH_3-Cl\\-NH_3-Cl\end{cases}, \quad Cr^{VI}_2\begin{cases}-NH_3-Cl\\-NH_3-Cl\\-NH_3-Cl\\-NH_3-NH_3-Cl\\-NH_3-Cl\\-NH_3-Cl\end{cases}, \quad Cr^{VI}_2\begin{cases}-NH_3-Cl\\-NH_3-Cl\\-NH_2-NH_3-Cl\\-NH_3-NH_3-Cl\\-NH_3-Cl\\-NH_3-Cl\end{cases},$$

Cleve suggests that the heptamin series may be only double salts of his tetramin and triamin compounds, and in view of the unsymmetrical structure of the chlorid this seems at least probable. It is also to be borne in mind that the want of symmetry is only seen if we adopt Blomstrand's theoretical views, and does not appear when the ammonia bases are formulated according to the principles of variable atomicity supported by the writer.* The invariable occurrence of two atoms of water in all the octamin compounds is difficult to explain upon any theory.—W. G.]

2. *On some new sulphur salts.*—Schneider has described some new sulphur salts belonging to the same class with those which we have already noticed. Potassio-platinous sulpho-platinate is easily obtained by fusing 1 or 2 parts of platinum sponge with 6 parts of pure potassic carbonate and six parts of sulphur, and treating the cooled mass with water. The author gives to this salt the formula:

$$K_2S, Pt''S, Pt''S, \rangle Pt^{IV}S_2$$

and points out its analogy to a copper salt described in a previous paper. The new compound forms small, hard, sharp and distinctly formed, six-sided tables of a blue gray color and strong metallic luster. The larger tables have a reddish tint and in thin layers are translucent with a red brown color. The density of the salt is 6·44. Dilute chlorhydric acid slowly dissolves out the potassium without the slightest evolution of sulphuretted hydrogen, the final product of the reaction being sesqui-sulphid of platinum Pt_2S_3 or platinous sulpho platinate PtS, PtS_2. This is a steel gray crystal-

* This Journal, vol. xlix, p. 108.

line powder of density 5·52, which when heated in the air burns like tinder and leaves pure spongy platinum. Sodio-platinous sulpho-platinate has a precisely analogous formula, sodium replacing potassium. It is a crystalline powder of density 6·27 and with a color between blue-gray and reddish lead-gray. A re-examination of the compound containing tin, platinum, potassium and sulphur, described in his previous paper, has led Schneider to the conclusion that this body contains no oxygen, and that its true formula is

$$K_2S, Pt''S, Pt''S, Pt''S \} Sn^{iv}S_2,$$

in which the quadrivalent platinum is replaced by quadrivalent tin. In addition to the sodium salt corresponding to the compound last formulated, Schneider describes a disodium salt which has the formula

$$Na_2S, Na_2S, Pt''S, Pt''s \} Pt^{iv}S_2.$$

When freshly prepared, this salt forms thin brilliant light copper red needles. It rapidly changes color in the air and becomes brown and finally almost black. Water dissolves it with partial decomposition, leaving a dark red crystalline powder of bisulphid of platinum. Schneider obtained by double decomposition silver and thallium salts corresponding to the disodium compound.—*Pogg. Ann.*. cxxxviii, 604. W. G.

3. *Synthesis of Hydroxylamin.*—By the action of tin and chlorhydric acid upon ethylic nitrate Lossen obtained the chlorhydrate of a new base, $NH_3\Theta$, which he termed hydroxylamin. Ludwig and Hein have succeeded in preparing this body by the direct addition of nascent hydrogen to nitric oxyd, expressing the reaction by the equation: $N\Theta + H_3 = NH_3\Theta$,

which is more correctly written $2N\Theta + 3H_2 = 2NH_3\Theta$. The nitric oxyd was prepared by the action of nitric acid upon ferrous sulphate and collected in a glass gasholder from which it was made to pass through a series of flasks containing tin and boiling chlorhydric acid. After separating the tin and ammonic chlorid the chlorhydrate of hydroxylamin was obtained with all the properties described by Lossen.—*Berichte der Deutschen Chem. Gesellschaft, 2ter Jahrgang*, p. 671. W. G.

4. *On a new group of double chlorids belonging to the platinum bases.*—By adding solutions of various metallic chlorids strongly acidulated with chlorhydric acid to a solution of the chlorid of Reiset's first base, $PtCl, 2NH_3$ or $4NH_3, PtCl_2, PtCl_2$, Buckton obtained a series of double chlorids embraced by the general formula $4NH_3, PtCl_2, PtCl_2$. Thomson has found that a second series of double chlorids of the same quantitative constitution but with wholly different properties is obtained by adding an ammoniacal solution of a metallic salt as copper, silver, nickel, &c., to a solution of double chlorid of platinum and ammonium, $PtCl_2, 2NH_4Cl$. The new salts are crystalline and vary in color according to the metal used; they are insoluble or with difficulty soluble in water and ammonia, but dissolve rather easily in dilute chlorhydric acid and are precipitated from this solution by ammonia. Buckton's salts are soluble in water and insoluble in chlorhydric acid.

W. G.

5. *A system of instruction in Quantitative Chemical Analysis;* by Dr. C. R. FRESENIUS, from the last English and German editions, edited by Prof. S. W. JOHNSON of Yale College. 8vo, pp. 631. New York: (John Wiley & Son). 1870.—In explanation of the alterations made in this American edition we quote the following from Prof. Johnson's preface.

"In preparing this edition of Fresenius' Quantitative Chemical Analysis, the editor has sought by various changes to adapt it to the wants of the American student.

The foreign editions have attained such encyclopedic dimensions as to occasion the beginner no little confusion and embarrassment. For this reason the bulk of the work has been considerably reduced. A few processes which the editor's experience has convinced him are untrustworthy, and many more that can well be spared because they are tedious or unnecessary, have been omitted.

The section on Organic Analysis has been reduced from sixty to thirty pages, mainly by the omission of processes which from their antiquity or inferiority are more curious than useful. The chapters on Acidimetry and Alkalimetry have been likewise greatly condensed, and all that especially relates to Soils and Ashes of Plants has been left out. The recent appearance of an excellent special treatise on "Agricultural Chemical Analysis" by Professor Caldwell, of Cornell University, justifies the last named omission.

On the other hand, some important matter has been added. Bunsen's invaluable new methods of treating precipitates are described in his own (translated) words. Various new methods of estimation and separation are incorporated in their proper places.

The additions which have been made to the methods of examining ores, it is believed, adapt the work to meet all the ordinary requirements of the metallurgical and mining student."

The editor acknowledges his indebtedness to Dr. Wolcott Gibbs, Dr. J. Lawrence Smith, Mr. O. D. Allen and others for important contributions and descriptions of new methods. We are confident that this excellent work will be of great service in advancing the study of analytical chemistry in this country, and that its publication will be welcomed by all teachers and students of quantitative chemical analysis.

6. *Effects of the Sun's Heat on a Sand Hill.*—Extract from a letter of GEO. DAVIDSON, Esq., of the Coast Survey, dated U. S. Coast Survey Station, San Buenaventura, Cal., January 23d, 1870, (communicated for this Journal, by Mr. D. B. Smith, of Germantown, Pa.)—I have had a very curious experience at this station. It is on the edge of a sandy, steep bluff, seventy feet above the low flat margin that extends 300 yards to the sea beach. At the station, I had an 18 inch theodolite, with three reading microscopes, and was engaged in determining the azimuth of the principal lines of the triangulation from the station San Buenaventura. This involved observations from sunrise to 10 A. M., and from 3½ P. M. to 11 P. M. Imagine my surprise when I found that the heat of the

sun pouring all the P. M. upon the southwest face of this bluff so expanded it that the level showed changes as great as 45″! Then in the evening contraction began, and continued until the level at sunrise exhibited changes of 45″ the other way. Here *was a change of* 1′ 30″ *certainly due to changes of temperature;* our lowest temperature was about 40°; our greatest about 79° in the shade, say 100° in the sun.

But this is not all: I was dismayed to find that in cooling during the evening, the tongue of the bluff upon which the station is situated, *twisted irregularly* in azimuth as much as 18″ in three hours. This, of course, vitiated all my results, and I continued a full series simply as an experiment, for I could not change my position for an eccentric one without many drawbacks. I did change my latitude instrument and transit from their positions near the station, and where the same phenomena were exhibited by them. At 102 yards from the edge of the bluff they are as steady as a rock, and I have nothing but the excessive undulations of the heated air to contend with.

7. *On the existence of Ammonium in the Ammoniacal Amalgam, and on a new Test for the presence of Nascent Hydrogen;* by ALBERT H. GALLATIN, M. D., of New York.—Berzelius and De Pontin in 1808, using the voltaic current as Davy had done, endeavored to do as much for the ammoniacal compounds as he had done for those of the fixed alkalies. They made what is known as the ammoniacal amalgam. That ammonium exists in this body has never been demonstrated, notwithstanding that its constituents in their proper proportions were always found escaping from the amalgam: that does not prove thea they were united; on the contrary, 2 vols. of NH_3 and 1 vol. of H are the products. Moreover, if it were ammonium, it had never been made to unite with any other metal than mercury. I have endeavored to overcome both of these objections.

If the hydrogen escaping from the mercury together with the ammonia can be shown to be in the nascent state, it would be evidence that it had just been in chemical combination with the ammonia, in other words, that metallic ammonium (NH_4) existed in the amalgam. Some pellets of sodium were placed in contact with some particles of the transparent variety of phosphorus, wrapped in bibulous paper and plunged beneath the surface of water. A red glow was seen; and the nascent hydrogen from the decomposing water came into contact with the phosphorus, bubbles of phosphid of hydrogen were formed. Occasionally one would flame as it came into contact with the atmosphere, placing the nature of the reaction beyond doubt. As phosphid of hydrogen cannot be formed by direct synthesis if ordinary free hydrogen be employed, this becomes a test for the presence of that gas in its nascent state. The hydrogen escaping from the ammoniacal amalgam was now tested by this process. A sodium-amalgam dipped beneath a solution of chlorid of ammonium was employed; and it became necessary to wait until the sodium was exhausted, that results might not be vitiated by the nascent hydrogen escap-

ing from the water. At the proper time the decomposing amalgam was covered with fragments of transparent phosphorus, when many bubbles of inflammable phosphid were obtained. The hydrogen must then have been in the nascent state and just escaping from the ammonium.—*Phil. Mag.*, xxxviii, 57.

8. *On the Existence of an Alloy of Ammonium and Bismuth, and on another new Test for the presence of Nascent Hydrogen;* by ALBERT H. GALLATIN, M. D., of New York.—Ammonium had never yet been seen united with any other metal than mercury. Mercury being the only metal fluid at ordinary temperatures, should another alloy be formed it would be solid. Some bismuth was melted in a porcelain dish and alloyed with sodium by dropping a piece of that metal on the clear surface of the fluid bismuth. Chlorid of ammonium was then dusted on the fluid alloy, and then water added in a fine quick stream. The bismuth swells, appears pasty and porous, and then congeals. Abundance of hydrogen escapes from the water, and the ammoniacal odor is set free. This body must now be dried. If it be placed near the ear a distinct crackling noise will be heard, a phenomenon which endures for some days. To ascertain if this be ammonium escaping from the bismuth, the body was placed beneath the surface of water, when bubbles of hydrogen escaped, easily to be collected and recognized; the ammonia, if any, must have been absorbed by the water. To test for this red litmus-paper was placed in the liquid. Wherever the currents from the bismuth struck it a blue spot became visible. On dissolving sulphate of copper in distilled water and placing the well-dried bismuth therein, the characteristic flocculi of ammonio-sulphate of copper appeared at once.

It remains to show that the hydrogen escaping is in the nascent state. There was not enough of it to test with phosphorus. The bismuth compound, when placed in a solution of sulphate of copper, becomes rapidly coated with metallic copper. Now bismuth unalloyed will not precipitate copper from its sulphate. To test if the precipitation of the metallic copper was due to the presence of nascent hydrogen, an alloy of bismuth and sodium was made and dipped in a solution of sulphate of copper. It instantly became coated with that metal, owing to the nascent hydrogen escaping from the water. The hydrogen was therefore escaping in the nascent state from the bismuth and ammonia, and therefore it was a true alloy of bismuth and ammonium. If the temperature of this alloy be raised, it will rapidly decompose with a crackling noise. On one occasion it exploded, sharply scattering the metal. The loud crackling noise produced by this substance may be heard for many days after it is made. That there is no mere surface-action in the case of the mercurial and bismuth alloys of ammonium, is shown by the pores which are formed by the escaping gases in both cases. In the amalgam these pores may be seen produced by the escaping ammonium long after the water has exhausted the sodium. In the mercurial body the pores are evanescent; in the case of bismuth they remain, and may be examined at leisure.

These are different phenomena from those displayed hy spongy platinum when it forces hydrogen and oxygen to combine.

Appendix.—Continuation of the investigation at the laboratory of the Royal Mint, London, by the kind permission of Mr. Roberts:—

The alloy was dried *in vacuo* over sulphuric acid. It was then heated *in vacuo* by means of a Sprengel pump, when it decomposed, and the resulting gas was collected over mercury. It was found to have twenty-seven times the volume of the original solid. Analysis of the gas proved it to contain nitrogen and hydrogen. The results of a further examination will shortly be given.—*Phil. Mag.*, IV, xxxviii, 58. June 23, 1869.

II. MINERALOGY AND GEOLOGY.

1. *Preliminary Field Report of the U. S. Geological Survey of Colorado and New Mexico*, conducted, under the authority of Hon. J. D. Cox, Secretary of the Interior, by F. V. Hayden, U. S. Geologist. 156 pp. 8vo. Washington, 1869.—Prof. Hayden, in this expedition of the year just past, was over his old field again, in which he has done so much by his observations and collections to promote the progress of American geology and paleontology. His explorations, however, were continued farther west, to and among the heights of the summit. His route was from Cheyenne, where he commenced his labors, to Denver; from Denver to the silver mines at Georgetown, the gold mines of Central City, and thence to the Middle Park; then back to Denver, and southward to Colorado City, Soda Springs, Cañon City, Spanish Peaks, Raton Hills, Fort Union, Mora Valley, and Santa Fé; thence up the Rio Grande, through the San Luis valley, Poncho Pass, Arkansas Valley, through the South Park to Denver again. Prof. Hayden remarks that "the coal formation along the base of the mountains was studied with great interest. With these coal beds are associated valuable deposits of brown iron ore. The coal and iron deposits of the Raton Hills extend from the Spanish Peaks to Maxwell's, and the supply of both is quite inexhaustible and of excellent quality. The future influence of these two important minerals at this locality, on the success of a Pacific Railroad, cannot be over-estimated. It is believed that the coal and iron mines of the Raton Hills will be of far more value to the country than all the mines of precious metals in that district.

The next locality for coal was at the Placiere Mountains. In one locality here, the coal has been changed into anthracite by the eruption of a basaltic dike, the igneous material of which had poured over the coal strata. Vast quantities of brown iron ore are associated with this coal, and magnetic iron ore is found in the gneissoid rocks of the mountain. The gold mines here are very rich and are now wrought upon a true scientific plan."

As this Report consists of field notes, the geological facts are present as they were observed along the principal routes; and we shall wait for a systematic review of the results from the author

before presenting them, and cite in this place only some of the paragraphs from his account of the trip to the famous "Middle Park."

Our route to the Middle Park was through the Berthoud Pass, from the valley of Clear Creek. The range of mountains in which the pass is located is composed of gneissic rocks—as are all the ranges in the mining districts. The ascent was very steep on the south side, up to the region of perpetual snow; but the descent on the north side is quite gradual.

Great quantities of loose materials from the basis rocks are scattered thickly over the summits, of every variety of the metamorphic class. Most of the peaks are well rounded, and covered with soil and vegetation. Grass and flowers grow far up above the limits of arborescent vegetation. As we ascend, the pines, spruces and cedars dwindle down in size, until they become recumbent and trail on the ground. Some of the highest peaks are very sharp, and covered with loose rocks, as if only the usual atmospheric influences had ever affected them. Their sides are often massive escarpments of rocks down which an infinite quantity of fragments have fallen, making a vast amount of debris at the base. Of course their rocky sides are entirely free from vegetation, and the oxyd of iron gives them a rusty reddish appearance. One mountain at the head of Clear Creek is called Red Mountain, from the fact that the rocks have a bright red color in the distance. The evidences of the outpouring of igneous rocks in this mountain are very marked; indeed, it may be called an eruptive range.

From the summit of Berthoud's Pass, at a height of eleven thousand eight hundred and sixteen feet, we can look northward along the line of the main range, which gradually flexes around to the northwest, while the little streams seem to flow through the rifts. The general appearance of the western slope of this great range would indicate that it is a huge anticlinal, composed of a series of ranges on each side of a common axis, and then smaller ranges ascend like steps to the central axis. The western side of this ridge slopes gently, while the eastern side projects over abruptly. This main range also forms a narrow dividing line, or "water-divide," between the waters of the Atlantic and Pacific. I stood where the waters of each side were only a few feet apart, and felt a real joy in passing down the western slope of the mountain by the side of a pure crystal stream whose waters were hastening on to the great Pacific.

The Middle Park is really made up of a number of smaller parks, which are somewhat independent of each other. Each one may present different geological formations. The little park on the south side, which we first enter, is a very beautiful one. The grass is luxuriant, and the timber excellent. None of the older sedimentary rocks were seen along the flanks of the mountains, but a recent tertiary deposit seemed to cover the country. On the east side of Fraser Creek there is a long high ridge, which is cut by the stream in several places, formed of the white and yellow sands and marls which mark the pliocene tertiary on the east side of the mountain. I have no doubt that it is a formation of the

same kind as that of the Arkansas marls, and cotemporaneous with it.

Along this creek there are some massive walls of this formation, mostly yellow marls, but some layers of sandstone. This ridge extends from the mountains far northward, and is about two miles wide; and between it and the immediate base of the mountains is situated a beautiful valley of considerable width.

The Middle Park is apparently a quaquaversal, surrounded by the lofty snowy ranges; and the lower ranges descending like steps to the valley which constitutes the true park. The park does not appear to be more than from ten to twenty miles wide from east to west, and from fifty to sixty long from north to south. In this park, also, the ranges of mountains so surround it that the slopes seem to form a sort of quaquaversal inclining toward a common center.

Viewed from Middle Park, Long's Peak, and the range immediately connected with, has a rugged, saw-like edge, as if composed of eruptive rocks, and ridge after ridge inclines from it in regular order.

About ten miles north of our camp, in the first park, we come to low ridges of massive red feldspathic granite, and parallel with these granite ridges are a series of sedimentary beds, commencing with the brick-red beds. The strike is nearly north and south, and the dip west. These ridges are all so grassed over that the true nature of the underlying rocks is not easily determined. Then comes ridge after ridge, untill all the beds—jurassic and cretaceous—are shown.

On this stream we have a fine system of terraces. On the north side are three distinct terraces above the bottom, and the lowest one has a bed of cretaceous sandstone, nearly horizontal, cropping out at its base. This is a low one, not more than fifteen feet high; the next one is fifty feet high, and the third, which descends from the high hills, is two hundred feet. A little west of south, at the junction of Grand River with Frazer Creek, five high peaks are visible, which form in that direction a part of the main range. All around us, in every direction, we could see the snowy peaks, and the beds which form the ridges of upheaval inclining in every direction.

To the south of the park, the older sedimentary rocks dip north in lofty ridges, at least two thousand feet high, presenting high escarpments when split by streams, and reaching almost the highest margin of the mountains.

About ten miles above the hot springs, Grand River flows through an enormous gorge cut through a high ridge of basalt, which seems to be an intrusive bed, for above and below the sedimentary rocks are well shown, but partially changed. Underneath are the cretaceous shales of Numbers 4 and 5, and above are the lignite tertiary beds. These beds all dip west 23°.

These eruptive rocks are very rough, as if they had been poured out without much pressure. Much of it is a very coarse conglomerate, the inclosed masses appearing to be the same kind as the

paste; that is, originally, of igneous origin. Some of the inclosed rocks are very compact, close, and all were more or less worn, before being inclosed. This rock is a true dolorite. I did not see any inclosed masses that I could call unchanged. This basalt extends a great distance, continuing a nearly uniform thickness, and inclining in the same direction with the cretaceous beds below and the tertiary beds above.

On both sides of Grand River, but especially on the east and northeast sides, extending up nearly to the foot of Long's Peak, are quite large exposures of the recent tertiary beds. They are nearly horizontal, and have much the appearance in color of the Fort Bridger beds, of which Church Buttes is an example. These beds are composed, for the most part, of fine sand and marl, but there are a few small rounded boulders scattered through it. Below the gorge, on the north side of Grand River, these outflows of basalt have formed some well-defined mesas; at least three beds, ascending like steps from the river. The basalt lies in horizontal beds, but on the south side is the sloping side of a basaltic ridge. The dip is nearly northwest, though the trend of this basaltic ridge is by no means regular. One portion of it has a strike northwest and southeast, and another north and south. The tertiary rocks reach a great thickness, and are elevated high up on the top of the basaltic ridge, eight hundred to one thousand feet above the river. They are mostly formed of fine sandstone and puddingstone. These fine sandstones contain some well-marked impressions of deciduous leaves, among which are good specimens of *Platanus haydeni*. On the north side of Grand River, in some localities, the tertiary beds are elevated so high, on many of the eruptive mountains, that they are covered with perpetual snow. These eruptive beds are certainly among the most remarkable examples of the overflow of igneous matter that I have ever seen in the West. * * * *

Immediately below the hot springs the Grand Cañon commences, and the river cuts its way through an upheaved ridge of massive feldspathic granite, for three miles, between walls from one thousand to one thousand five hundred feet high. The south side is somewhat sloping, and covered thickly with pines, while the north side is extremely rugged, the immense projecting masses of granite forbidding any vegetation to gain a foothold. It would seem that the river had worn its way through a sort of rift in the granite, but at the upper end it has cut through the uplifted sedimentary ridges nearly at right angles. In some places the north side is gashed out in a wonderfully picturesque manner, so that isolated columns and peaks are left standing, while all the intermediate portions have been worn away. This granite ridge will average perhaps five miles in width, and extends an unknown distance across the park, northeast and southwest, and it is from the southeast side that the ridges of upheaval, above described, incline.

The granite ridge seems to form a sort of abrupt anticlinal. On the southeast side the rocks all are bare, or covered with a super-

ficial deposit of recent tertiary marls. None of the older unchanged rocks are seen on this side, but the modern sands and sandstones are exposed in a horizontal position in the channel of the river.

The hot springs are located on the right bank of Grand River, at the juncture of the sedimentary rocks with the granites. Just east of the springs is a high hill, Mount Bross, one thousand to one thousand two hundred feet above Grand River, which seems to be composed mostly of the older tertiary strata, alternate yellow and gray sandstones, and laminated arenaceous shaly clays. The whole is so grassed over, that it is difficult to take a section. The beds incline east of north at a small angle. I regard the beds as of the age of the coal formations of the West, older tertiary. I found excellent impressions of deciduous leaves, among which are those of the genus *Magnolia*. Just opposite the springs, the left bank of the river shows a perfect section of all the layers, from the cretaceous to the jurassic. The bank is not more than ten feet thick above the water, and yet it shows that the river itself rolls over the upturned edges of all these beds.

The section in descending order is as follows:

1. *Tertiary* strata, forming the greater part of the hill known as Mount Bross. The *Cretaceous*, consisting of—

2. Gray laminated sandstones, passing down into arenaceous clays, with *Baculites ovatus*, &c.

3. Black clays of No. 4. These are of great thickness, and every variety of texture. As shown in a cut bank of the river, it is yellow arenaceous clay, with layers of sandstone, in which the impressions of deciduous leaves were observed. These layers project up, a distance along the bank, of seventy paces.

4. Dark plastic clay, with cone in cone, seams of impure clay, iron ore. Then comes an interval in which no layers could be seen, sufficient to include No. 3—two hundred and fifty paces.

5. Dark steel-black laminated slate, with numerous fish scales; dip twenty-seven degrees. This slate passes down into alternate layers of rusty sandstone and shaly clay. * * * *

I have given this detailed description of the cretaceous rocks to show the exceeding variableness of their texture, and also to call the attention of scientific men, who may hereafter visit this interesting locality, which will soon become celebrated, to a section of the rock through which the waters of the spring must pass in reaching the surface. Now, in whatever rocks these springs may originate, the water must pass a long distance through the almost vertical strata of the Cretaceous period, in the sediments of which are found in other localities nearly all and perhaps all the mineral constituents found in these springs. The deposits around these springs are very extensive. No analysis has as yet been made, but large masses of gypsum and native sulphur can be taken out at any time from the sides of the large basin-like depression into which the water flows. They are properly "Hot Sulphur Springs," varying in temperature from 80 to 112°.

Troublesome Cañon, at the head of the creek bearing this name, is entirely basaltic, and the rugged walls, not only of the main stream, but also of the little branches, form a most picturesque view.

Below the Cañon, the valley of Troublesome Creek, and also that of Grand River near the junction, is occupied by belts of modern tertiary sands and marls, like those observed at the entrance to the park, by Berthoud's Pass. Where the little stream cuts the terraces, horizontal strata of whitish and flesh-colored sands and marls are exposed. I looked in vain for fossils, and found only specimens of silicified wood. There are cold sulphur springs in this valley. All through the park, the benches or terraces are conspicuous in the vicinity of streams, as at the base of mountain ranges. In the park through which Frazer's Creek flows, these benches or terraces are most beautifully carved out from the modern marls.

In summing up the geology of Middle Park, we find that all the sedimentary rocks known in this country are found there. I did not see any beds that I could define as carboniferous, but the triassic, jurassic, cretaceous, and tertiary are well developed. I have no doubt as to the existence of true carboniferous limestones in the Middle Park.

The tertiary deposits of this region may be divided into two groups, viz., the lignite or older tertiary, and the modern pliocene marls and sands, which seem common to the parks and mountain valleys. The former conform perfectly to the older beds, while the latter seldom incline more than three to five degrees, and do not conform to the older rocks. The marl group is undoubtedly contemporaneous with the Arkansas and Sante Fé marls.

This volume contains also a valuable Report of P. Frazer, Jr., on the mines and minerals of Colorado, and another by Cyrus Thomas, on the agriculture of Colorado.

2. *The Gold Fields and Mineral Districts of Victoria, with Notes on the Modes of Occurrence of Gold and other Metals and Minerals;* by R. Brough Smyth, F.G.S., &c., Secretary for Mines for the colony of Victoria, Melbourne. 644 pp. Royal 8vo. 1869. (Trübner & Co.)—We have examined this elaborate volume with equal pleasure and instruction. It is, in fact, an extensive treatise, full of minute details and exact information rendered in an unpretending matter of fact style. The work is illustrated by plans, sections, sketches, diagrams and maps, and is carefully printed and accompanied by ample tabular statements, statistical and otherwise.

Perhaps the most striking thing brought to light by the Victoria gold fields, to one who is also familiar with those of California, is the fact that, to all appearance, the area of the Australian fields yet unexplored, or very imperfectly so, is vastly greater than any reserves known to exist upon the Pacific slopes of North America. Of a minimum of 20,000,000 acres of known gold fields in Victoria,

not more than 600,000 acres, or one thirty-third part, have been opened and explored, while many of the older districts are still yielding, with improved methods and economy, better results than at any former period. The fact of the general similarity of the modes of occurrence of gold in gulches, deep lying placers, and in old river courses, under lava, and basalt, in Australia and California, has long been known, but the subject receives new and valuable illustration by the labors of Mr. Smyth. Hitherto comparatively little has been known in this country respecting the modes of occurrence and productiveness of the gold-quartz mines—*reefs*, as they are called—in Victoria. This want Mr. Smyth fully supplies. He tabulates the course and direction of nearly 500 quartz veins in the several mining districts, the directions being from N. 89° W. to N. 47° E.; but by far the greater number of veins run about N. 30° to 40° W.; and mention is made of results obtained from the workings of over 2400 mining companies, mostly engaged upon quartz. The number of quartz reefs (veins), actually proved to be auriferous, is over 2,600, and the total extent in square miles of auriferous alluvial and quartz ground worked upon is upwards of 880 square miles.

The average yield of gold from certain parcels of quartz, the details of which are given from 1859 to 1868, from returns made to the Mining Surveyor and Registrars, is shown to be from 5,816,669 tons 9 cwts. of quartz crushed, 3,346,201 oz. 8 dwts. of gold or an average, per ton of 11 dwts. 12·37 grains. This value is very unequally distributed between the different districts, as appears from an inspection of the details tabulated in the appendix. The average fineness of the Australian gold is considerably above that of California.

Full and very interesting details are given of several of the most important quartz mining operations, of which the Port Philip Co., at Clunes, is the most important. The following is a return of quartz crushed at Clunes for the 12 months ending September, 1865, viz.: 54,413 tons of quartz crushed yielded 20,596 oz. 10 dwts. 12 grains of gold, averaging 7 dwts. 13 grains per ton, and valued at $20 per oz.=$417,920. To crush this amount of quartz, 80 stamps were required, viz.: 56 heads of about 6 cwts., each striking 75 blows per minute, requiring about one horse power each, and crushing an average of about 2 tons, 4 cwts. each; while 24 stamps weighing about 8 cwts. each, crush 4 tons per diem each of fine material; about 8 gallons of water per head per minute is required by these stamps, or 921,600 gallons per diem. Two steam engines drive the stamps. Of the total gold saved, 66·08 per cent are found in the stamp beds, 22·95 in the mercury-boxes, and 10·97 comes from the blankets.

Compared with the best California mines, the yield per ton of the St. Philiip, is small. Thus in 1868–9, 20,638 tons of gold quartz crushed at the Eureka Mill, Grass Valley, California, yielded $537,687.89, or an average of $27.80 per ton of ore; and this is considerably less than the average of some former years. The aver-

age of the Amador Company, Sutter Creek, on a somewhat greater crushing is over $25 per ton, and has steadily increased from $5 or $6 to the present rate in sinking to a depth of 1200 feet, which is double the depth of the St. Phillips, at Clunes.

Mr. Smyth discusses at length Sir Roderick Murchison's notion that quartz gold veins become poorer in depth, and effectually proves that there is no evidence of this; but after a careful comparison of over 200 examples, he announces the following general conclusions: 'Taking the whole of the information and results obtained into consideration, there is much reasonable evidence produced in support of the theory *that quartz reefs are richer as they increase in depth*, and in addition to this, *that they are wider*.'

A remarkable feature of the Australian gold fields, in which they are distinguished above all others, is the magnitude and frequency of the nuggets found in them. Mr. Smyth gives two interesting tabular statements of remarkable nuggets, the history of which is known, as compiled by Mr. Birkmyre, an experienced assayer, and the second by Mr. F. Knox Orme, the warden of Dunolly. Of Mr. Birkmyre's list (over 150 specimens), only 27 are American or European. We enumerate a few of the most remarkable Australian nuggets, compiled from both tables:

	lbs.	oz.
Dunolly, date, &c., unknown,	248½	
The "Welcome Stranger Nugget," found Feb. 2d, 1869, in the auriferous alluvium, near Bull Dog Reef, Dunolly, Victoria; 21 inches long, 10 inches in thickness; mixed with the quartz, but the great body of it solid gold; 986 fine; value £9534. The neighborhood of Dunolly is almost an unprospected country. For many miles there are out-cropping reefs which have yielded very large pieces of gold.	190	10
The "Welcome Nugget," found June 15, 1858, at Bakery Hill, Ballaarat, Victoria, at 180 feet depth; water-worn and irregular shaped; 20 inches long by 12 broad and 7 deep; by assay, 992 fine; value, £9.325.	184	9
The "Blanche Barkly Nugget," found 27th August, 1857, at Kingower, Victoria, at a depth of 13 feet, and within five or six feet of holes dug three years before. It measured 28 inches by 10, and contained about two lbs. of quartz, clay, &c.; assay, 955; value, £6.905.12.	145	3
Found at Canadian Gully, Ballaarat, Victoria, 31st of January, 1853, at a depth of 60 feet; 989 fine; value, £5.532 7s. 4d.	134	11
Found in July, 1851, by a native boy, in a heap of quartz at Meroo Creek, River Turon, 53 miles from Bathurst, N. S. W. It was in three pieces when found, though considered as one mass.	106	
Found in 1857 at Dunolly, Victoria, two specimens with gold distributed through a rust-colored matrix.	237	
Found Nov. 1st, 1858, at Burrandong, near Orange, N. S. W., at a depth of 35 feet, mingled with quartz and pyrites; of 874 fineness.	107	2
The "Lady Hamilton Nugget," found 1854, Sept. 8th, near Canadian Gully, Ballaarat, Victoria, at a depth of 135 feet.	98	1

Did space permit, this list might be continued, by far the larger number of nuggets found being under 100 lbs. Troy, and the history of some of them is sufficiently curious. Many of the large nuggets of Australia are distinctly referred to quartz veins in the immediate vicinity, and masses are specified of several pounds weight, which have been found attached to the veins. How rare this circumstance is in California, is well known; the only example

of much significance being in the Morgan claim on Carson Hill. The famous Cabarras Co. (N. C.), (1821,) nugget of 34 lbs. weight was alluvial gold. The largest nugget found in California was at Valiceto, (24th April, 1852), near Carson Hill, and weighing 25 lbs. 5 ounces.

The following tables exhibit interesting information.

Returns showing approximately the gold obtained from quartz veins and alluvial workings during the years 1864 *to* 1868 *inclusive, Victoria:*

Year.	From Quartz Veins.		From Alluvial Workings.	
	oz.	dwts.	oz.	dwts.
1864	503,618	5	1,041,076	10
1865	450,000	0	1,093,801	0
1866	521,017	0	958,177	15
1867	560,527	0	873,160	6
1868	587,694	0	1,069,804	0

The ratio of quartz gold to alluvial gold is thus shown to be much higher in Australia than it is in California, where not over one quarter of the annual production is considered to arise from quartz, while in Victoria it is seen to be about one half.

Yield of Gold per annum: Victoria.

Year.	Quantity Exported. ounces.	Value at 80s. per oz.
1851 for 3 mos.	145,146	580,584
1852	2,218,782	8,875,128
1853	2,676,345	10,705,380
1854	2,150,730	8,602,920
1855	2,751,535	11,006,140
1856	2,985,991	11,943,964
1857	2,762,460	11,049,840
1858	2,528,478	10,113,912
1859	2,280,950	9,123,800
1860	2,156,660	8,626,640
1861	1,967,420	7,869,680
1862	1,658,207	6,632,828
1863	1,626,872	6,507,488
1864	1,544,694	6,178,776
1865	1,543,801	6,175,204
1866	1,479,194	5,916,776
1867	1,433,687	5,734,748
1868	1,657,498	6,629,992
Totals,	35,568,450	132,273,800

To arrive at the total quantity exported, it is necessary to add 1,267,241 ozs. to the above.

Mr. Smith's volume contains ample material for study, and offers many tempting extracts, but our space compels us to forbear.

3. *On Old Water Courses;* by Dr. J. S. NEWBERRY.—(To the citations from the memoir of Dr. Newberry on Surface Geology at page 111, we here add the following.—EDS.)

"Some of the valleys and channels which bear the marks of glacial action—evidently formed or modified by ice, and dating from the ice period or an earlier epoch—are excavated far below the present lakes and water-courses which occupy them.

These valleys form a connected system of drainage, at a lower level than the present river system, and lower than could be produced without a continental elevation of several hundred feet. A few examples will suffice to show on what evidence this assertion is based.

Lake Michigan, Lake Huron, Lake Erie, and Lake Ontario are basins excavated in undisturbed sedimentary rocks. Of these, Lake Michigan is 600 feet deep, with a surface level of 578 feet above tides; Lake Huron is 500 feet deep, with a surface level of 574 feet; Lake Erie is 204 feet deep, with a surface level of 565 feet; Lake Ontario is 450 feet deep, with a surface level of 234 feet above the sea.

An old, excavated, now-filled channel connects Lake Erie and Lake Huron. At Detroit the rock surface is 130 feet below the city. In the oil region of Bothwell, &c., from 50 to 200 feet of clay overlie the rock. What the greatest depth of this channel is, is not known.

An excavated trough runs south from Lake Michigan—filled with clay, sand, tree trunks, &c.—penetrated at Bloomington, Ill., to the depth of 230 feet.

The rock bottoms of the troughs of the Mississippi and Missouri, near their junction or below, have never been reached; but they are many feet, perhaps some hundreds, beneath the present stream-beds.

The borings for oil in the valleys of the Western rivers have enabled me not only to demonstrate the existence of deeply buried channels of excavation, but in many cases to map them out. Oil Creek flows from 75 to 100 feet above its old channel, and that channel had sometimes vertical and even over-hanging cliffs. The Beaver, at the junction of the Mahoning and Shenango, runs 150 feet above the bottom of its old trough.

The Ohio throughout its entire course runs in a valley which has been cut nowhere less than 150 feet below the present river.

The Cuyahoga enters Lake Erie at Cleveland, more than 100 feet above the rock bottom of its excavated trough. The Chagrin, Vermilion, and other streams running into Lake Erie exhibit the same phenomena, and prove that the surface level of the lake must have once been at least 100 feet lower than now.

The bottom of the excavated channel in which Onondaga Lake is situated, and the Salina salt-wells bored, is at least 414 feet below the surface level of the lake and 50 feet below the sea level. (Geddes. Trans. New York State Agricultural Society, 1859.)

The old channel of the Genesee River at Portage, described by

Prof. Hall in the Geology of the 4th District of New York; the trough of the Hudson, traceable on the sea bottom nearly 100 miles from the present river mouth; the deeply buried bed of the Lower Mississippi, are additional examples of the same kind; while the depth to which the Golden Gate, the Straits of Carquinez, the channel of the lower Columbia, the Canal de Haro, Hood's Canal, Puget Sound, &c., have been excavated, indicates a similar (perhaps simultaneous) elevation and erosion of the Western coast of America.

The falls of the Ohio—formed by a rocky barrier across the stream—though at first sight seeming to disprove the theory of a deep continuous channel in our Western rivers, really afford no argument against it, for here, as in many other instances, the present river does not follow accurately the line of the old channel below, but runs along one or the other side of it. In the case of the Louisville falls the Ohio runs across a rocky point which projects into the old valley from the north side, while the deep channel passes under the lowland on the south side, on part of which the city of Louisville is built.

The importance of a knowledge of these old channels in the improvement of the navigation of our larger rivers is obvious, and it is possible it would have led to the adoption of other means than a rock canal for passing the Louisville falls, had it been possessed by those concerned in this enterprise.

I ventured to predict to Gen. Warren that an old filled-up channel would be found passing around the Mississippi rapids, and his examinations have confirmed the prophecy. I will venture still further, and predict the discovery of buried channels of communication between Lake Superior and Lake Michigan—probably somewhere near and east of the Grand Sable—at least, between the Pictured Rocks and the St. Mary's River—between Lake Erie and Lake Ontario through Canada,—between Lake Ontario* and the Hudson by the valley of the Mohawk,—between Lake Michigan and the Mississippi, somewhere along the line I have before indicated. I also regard it probable that a channel may be found connecting the upper and lower portions of the Tennessee River, passing around the Mussel Shoals. This locality lies outside of the area where the Northern Drift deposits were laid down to fill and conceal ancient channels, but the excavation and the filling up of the channel of the Tennessee—like that of the

* When the water in the lake basin had subsided to near its present level, its old avenues of escape being all silted up by the Drift clays and sands the surplus made its exit by the line of lowest levels wherever that chanced to run. As that happened to lie over the rocky point that projected from the northern extremity of the Alleghanies into the lake basin, there the line of drainage was established in what is now known as Niagara river.

Though among the most recent of the events recorded in our surface geology, this choice of the Niagara outlet by the lake waters was made so long ago that all the erosion of the gorge below the falls has been accomplished since. The excavation of the basin into which the Niagara flows—the basin of Lake Ontario, of which Queenstown Heights form part of the margin—belongs to an epoch long anterior.

Ohio —were determined by the relative altitude of the waters of the Gulf. The channel of the Lower Tennessee must have been excavated when the southern portion of the Mississippi valley was higher above the Gulf level than now, and Prof. Hilgard has shown that at a subsequent period, probably during the Champlain epoch, the Gulf coast was depressed 500 feet below its present relative level. This depression must have made the Lower Mississippi an arm of the sea, by which the flow of the Ohio and Tennessee was arrested, their channels filled, terraces formed, &c. If the Upper Tennessee has, as appears, a channel lower than the Mussel Shoals, it must be somewhere connected with the deep channel of the lower river.

4. *The Volcano of Kilauea, and great Earthquake Waves;* by Rev. TITUS COAN.—I have lately returned from a tour of exploration to the active crater of Kilauea and the volcanic district of Puna. At Kilauea the action was dull. The central area of this immense crater remains a deep concavity, depressed about 400 feet below its margin; but this margin is a new rim or black ledge of lava, itself depressed a thousand feet below the banks of the crater, and marking the former level of its bottom. In this profound basin I noticed a scanty growth of ferns rooted in the superficial strata of lava. They had gone down uninjured to a depth of 400 or 500 feet, as the crust subsided upon the disgorgement of the molten lava beneath. The old South Lake retains its locality; but its contours are entirely changed. It is now a nearly circular pit, about 400 feet deep in the bottom of the crater. Its diameter, as I measured, is four-fifths of a mile, and its walls, of black hardened lava, are jagged and frowning; in some places beetling; in others, perpendicular or retreating. To this abyss access is anything but easy; it is possible to enter it at but a single place, and by making a *trajet* over a steep, rugged, and difficult incline of *debris*, yet a brave American lady of my party ventured to descend under my guidance. Here, 2,000 feet below the surface of the ground, we tramped together over the floor of the awful pit. It seems now the half-cooled forge of Vulcan. The fiery billows no longer roll and break as they were wont to do over this vast area of indurated lavas; yet, in many places we could look into red-hot ovens and chimneys, and down through orifices in the crust to the molten sea below, and hear, and see, and feel the incandescent minerals boiling, and surging, lashing the sides of the deep cavern, and sending up volumes of white sulphur vapors. But now this principal focus of volcanic action is comparatively quiet. Our last great eruption has lowered its fiery tides far below their usual level; and we are content to enjoy this lull in the strife of the telluric forces which are so ably described in Dr. C. F. Winslow's recent work on Force and Nature—a work which gives the completest explanation that has yet appeared of volcanic phenomena in Hawaii. I spent three days at Kilauea, making careful observations of the crater; and, when these were completed, went to the seashore at Ke-a-la-ko-mo, a village in the volcanic district of Puna, situated about twenty

miles from Kilauea. In this district the subsidence of the land was distinctly marked. Throughout a coast line of many miles in extent the shore has settled from six to eight feet.

On the 25th of July last a remarkable flood tide visited the southern shore of Puna, tearing away the faces of the sea-cliffs, sweeping over barriers 25 feet high, rolling in foaming surfs hundreds of feet inland, and carrying with it huge boulders and angular masses of rock of from a ton to three tons in weight. The sea rose nearly *thirty feet* in perpendicular height, or ten feet higher than the great earthquake wave, already described in your Journal, of the 2nd April, 1868. Several houses which were not reached by that wave were swept away on the 25th. By the latter calamity nearly everything has been destroyed upon the high shores of Ka-ha-na-le-a, and the delicious bath in the fissure at Pu-na-luu is doubled in depth. Nor are the changes that the plastic volcanic agency is impressing upon this country yet completed. At Ka-la-pa-na the sea is more and more invading the land. Two channels are opened through the beach, and the tide ebbs and flows over large fields of the Ka-la-pa-na plain. The old stone church of the village is deeply buried in sand and boulders, and the tides sweep entirely over it. From Ka-mai li to Ka-po-ho the shores are terribly torn by the action of the waves. Between the villages of O-pi-hi-kaa and Po-ho-i-ki the waves dashed a thousand feet inland and destroyed a mile of road running parallel with the shore, upon a line never before reached by the sea. But for the declivity of our shores, these gigantic waves would have penetrated much further inland. The point of disturbance, from which these remarkable waves radiated, is still unknown to us. The focus of the great Peruvian earthquakes of 1868 was near the city of Arica, where the first shocks were felt at 4¾ P. M., Aug. 13. The resulting earthquake wave reached our islands, a distance of 6,000 miles to the northwest, late at night *upon the same day*, and, traveling toward the southwest, reached the harbor of Lyttleton, New Zealand, at 4¾ o'clock in the morning of the 15th. Making the allowances in time required by a difference in longitude of 243 deg. 18 min. (counting eastward), it appears that the wave occupied but 19 hours and 17 minutes in making the latter distance of 7,200 miles. This makes 368 miles per hour, or 540 feet per second, about half the nominal velocity of a cannon-ball. On the 23d of December, 1854, a similar wave was transmitted across the entire breadth of the Pacific Ocean, from Japan to California, in 12 hours and 38 minutes. The great earthquake wave of April 20, 1868, passed from our Hawaiian shores to the coasts of Mexico, California, and Oregon, in *five hours'* time, as indicated by self-registering tide-gauges at San Francisco and Astoria, which announced its arrival upon the evening of the same day in which it had desolated the coasts of Puna and of Ka-u. These waves are entirely distinct from the tidal swing of the ocean, and are proper *waves of translation.—N. Y. Tribune.*

I returned to Hilo by the coast-route, experiencing occasional earthquakes by the way, some of them a little startling. These still continue at intervals; but we are inclined to expect a season of comparative volcanic quiet at present, and have no sensation, in the way of natural phenomena, in definite prospect earlier than the transit of Venus in 1874. We are already promised visits by scientific observers upon that occasion.

5. *A Treatise on Ore Deposits*; by BERNHARD VON COTTA, Professor of Geology in the Royal Saxon School of Mines; translated from the second German edition, by FREDERICK PRIME, Jr., Mining Engineer. 594 pp. 8vo. New York, 1870. (D. Van Nostrand).—Mr. Prime has done a good thing for all interested in the study of ore deposits, in giving us a translation of Van Cotta's "Erzlagerstättenlehre." This book has long been the standard authority in Germany, and we are fortunate in now having an edition of it in English, which is even more complete than the last German edition, as Mr. Prime not only had the approval and permission of the author, to translate the work, but Prof. v. Cotta also has made alterations and furnished additions to it, so that it is in reality a new edition. The work commences with a general discussion of the different kinds of metalliferous deposits, covering some 90 pages, and then takes up, by way of illustration, the description of the most important mining districts of Europe, closing with a chapter of theoretical considerations, suggested by the observed facts. We trust that the publication of this excellent work will inspire our mining engineers and geologists with a sense of the importance of carefully observing and recording the facts connected with the occurrence of ore deposits in this country. The work already done by some of our best observers, especially such admirable researches as those of Prof. J. D. Whitney on the Upper Mississippi lead region, shows what may be done. The forthcoming reports of the California survey, and of the survey of the 40th parallel, will undoubtedly furnish a large amount of new material, which, with the facts already published in various geological and mining reports, might form the basis of a work on American "ore deposits," that would very appropriately supplement Mr. Prime's translation of von Cotta's book, and give a still further impulse to this important study.

6. *Notice of Asbestus and Corundum with other Minerals at Pelham, Mass.*; by J. H. ADAMS, Senior in Amherst College.—In the towns of Pelham and Shutesbury, Mass., there are several localities of asbestus, known to the mineralogists in this part of the state, although no special mention is made of them in any scientific work, they being scarcely noticed in the geological survey. Surface specimens of indifferent quality have been common in collections for years. Dark colored pieces, hard and compact, have sometimes passed for petrified wood, to which there is a strong resemblance. The most noted of those localities, is on the land of Mr. Samuel Newell in Pelham. Recent excavations to obtain asbestus for economical purposes reveal its presence here in great

quantity. Much of it is soft, of a grayish-white color, composed of delicate parallel fibers, often one foot in length, with a marked cross cleavage oblique to the fibers, as in hornblende.

Intimately associated with the asbestus, is an altered mica, allied to vermiculite or jefferisite. This appears in irregular veins, separated by a decomposed asbestiform mineral, and granular actinolite, which crumbles upon exposure. It occurs in loose foliated scales and small angular aggregations, occasionally several inches in size. Hardness, about 1·5. Luster pearly, sometimes metallic. Color light brass-yellow to yellowish brown, scarcely transparent, even in very thin folia. Flexible, inelastic. Before the blowpipe exfoliates remarkably, and at last fuses slightly on the edges. This property however is variable. Of five specimens taken, only two exfoliated in a marked degree. The laminæ after heating appear as if melted or pressed together, and not readily separating. It differs in this respect from the jefferisite of Westchester, Pa., but seems to resemble it in optical characters. Both exhibit a six-rayed astersim, although from its extreme opacity a sufficient thin lamina of the Pelham mineral is obtained with difficulty.

These veins of altered mica are free from admixture with soil or other minerals; and the substance is often so loose as to be readily displaced by the hand without the aid of a pick. Farmers use it as an absorbent for bedding cattle. Might it not be of service in other ways?*

Not the least interesting circumstance, however, is the presence at this spot of corundum. Flattened masses of brownish-black mica, superior in hardness to the surrounding mineral, contain nodules of corundophilite which inclose a white corundum. It is often streaked of a deep sapphire blue. This is, I think, the second observation of the kind in northern New England, the other locality being at Chester. It rarely occurs in situ, and in small quantity; but doubtless farther excavations will develop more valuable specimens. The locality promises considerable interest to the mineralogist; and it is believed that the asbestus may prove of sufficient value to warrant mining.

Amherst College, Nov. 13, 1869.

7. *Note on the Remains of Fossil Birds;* by O. C. Marsh.—Just after the article on pages 205 to 217 had gone to press, I received from Professor F. V. Hayden a unique specimen, which forms a most interesting addition to the fossil bird remains there described. It is the distal portion of a large feather, with the shaft and vane in such excellent preservation, that it may perhaps indicate approximately the nature of the bird to which it belonged. The specimen was discovered in a fresh-water Tertiary deposit, of the Green River group, in Wyoming Territory, and will be figured and described in full with the osseous remains noticed in the above article.

* A similar mineral is used in Europe for sanding paper, in place of blotters.

8. *The Dinornis and Saurian remains in Australia;* by Rev. W. B. CLARKE.—A femur of a species of Moa or Dinornis has been announced by Rev. W. B. Clarke as found in the Pleistocene drift of Peak Downs, Australia. The femur was probably buried in a fresh water fluviatile drift, over which was formed a lacustrine deposit. Mr. Clarke regards the discovery as evidence of the former connection of Australia and New Zealand, and makes the following additional observations on the subject. "Returning, in conclusion, to the supposed connections, in former geological times, of New Zealand and Australia, a fresh testimony has been offered to me within the last few days, in the statement of a discovery during the last few months of abundant remains of Saurian reptiles along the Waipara River in New Zealand, of the same kind as those which have been found to occur along the Flinders River in Queensland, and which, in addition to the Plesiosaurus discovered by the same friend, Mr. Hood, show that there was a similar geological fauna in times as far back at least, as the Cretaceous period. The Plesiosaurus was mentioned in my paper 'On recent geological discoveries in Australasia' (1861). Although now the flora is dissimilar, yet there is evidence that in even earlier geological times, such as our Carboniferous epoch, for instance, there was a similar flora.

"The views I have adopted lead me to maintain, that we in Australia inhabit only a fragment of a vast continent, of which in New Zealand there was probably, as there still is, the culminating ridge or the highest portion of Pacific dry land. That this opinion is not without support, I find, by a passage in Dr. Mantell's account of his son's discoveries of Dinornis. Without remembering that passage (which, indeed, I am not sure I ever read till this evening), I have expressed myself in language nearly identical with that of Dr. Mantell, who says, in 1850, 'It seems probable that these stupendous animals were not anciently confined within the narrow limits of modern New Zealand, but ranged over a vast continent, that is now *submerged*, and of which the isles of the Pacific are the culminating points.'"

9. *Synopsis of the Extinct Mammalia of the Cave Formations in the United States, with observations on some Myriapoda found in and near the same, and on some Extinct Mammals of the Caves of Anguilla, W. I., and of other localities;* by EDWARD D. COPE. (From the Proceedings of the American Philosophical Society, Philadelphia, vol. xi, p. 171, 1869.)—This includes an account of remains of mammals discovered in a cave breccia in Wythe county, Virginia, by the author, among which several extinct forms occurred associated with existing species. The new species are *Stereodectes tortus* (gen. et sp. nov.) allied to *Arctomys; Tamias lævidens; Sciurus panolius; Mixophagus spelæus; Galera perdicida.* Associated extinct species are *Megalonyx Jeffersonii; Tapirus Haysii; Dicotyles nasutus; Ursus amplidens*, and others. Among the recent species are *Castor fiber; Neotoma? Floridanaum; Lepus sylvaticus; Cariacus* (*Cervus*) *Virginianus; Procyon*

lotor, etc. The species previously described by Le Conte and Leidy, from a similar deposit in the lead-bearing limestone of Galena, Ill., are also included in the list. The whole number of species is 27, of which 14 are extinct and represent 5 extinct genera, while 6 genera are of "neotropical type." Seven species of land shells, and remains of reptiles and birds were also found. The species of *Myriapoda* obtained are enumerated and several new species and a new genus, *Androgmathus*, are described. In the second part of the paper two genera of gigantic rodents from Anguilla are described: *Amblyrhiza inundata* and *Loxomylus longidens*. In connection with these a human instrument of shell was discovered. The third contains descriptions of *Anoplanassa forcipata*, a new genus and species of Cetacea from near Savannah, Georgia, and *Hemicaulodon effodiens*, a large Sirenian allied to the Dugong, from the Eocene Marl of Monmouth county, N. J. v.

10. *The Extinct Mammalian Fauna of Dakota and Nebraska*, including an account of some allied forms from other localities, together with a *Synopsis of the Mammalian remains of North America*, illustrated with 30 plates; by JOSEPH LEIDY, M.D., LL.D., Professor of Anatomy in the University of Pennsylvania; preceded with an introduction on the *Geology of the Tertiary Formations of Dakota and Nebraska*, accompanied with a map; by F. V. HAYDEN, M.D., Professor of Mineralogy and Geology in the University of Pennsylvania, etc. Vol. VII, of 2nd series, of the Journal of the Academy of Natural Sciences of Philadelphia. Philadelphia, 1869.—In this large and beautiful volume, issued by the Academy of Sciences of Philadelphia, Dr. Leidy has given a thorough revision of all his own labors and those of others, with regard to the ancient Mammalian Fauna of the Upper Missouri region. As he observes in his preface, the materials for this work "have been gradually and continuously accumulating for the last twenty-three years." Through the new facts which have come to light, the author has been enabled to revise his former determinations of species, and to write out the characteristics of each with far more precision and fullness. The synonymy is well worked up and contains many points of historical interest. The value of the work is much enhanced by the addition of the "Synopsis of the Mammalian remains of North America," which occupies 84 pages of the volume, and must have cost the author a vast amount of labor. The thirty lithographic plates show exactness in delineation, and illustrate not only the species of the Nebraska region, but also several of those of other parts of the country.

A large part of the personal observations on the geology of the region, and of the collections of its fossils have been made by Prof. F. V. Hayden, and it is therefore especially appropriate that the introductory chapter should have come from his pen. A large colored map of the geology of the region accompanies the work which was also prepared by Prof. Hayden. A further analysis of the work we have to defer to another occasion.

11. *On the Geology of the New Haven Region, with special reference to the orign of its Topographical features;* by JAMES D. DANA. 70 pp. 8vo, with a map. From vol. II, of the Transactions of the Connecticut Academy.—The author concludes, from the facts brought out in this paper, "that, by special facts, and by the course of events, this region in the Glacial era, like that of New England to the North, was moulded at surface largely by the action of the Connecticut valley glacier and its underflowing streams, and covered through the subsequent melting of the iee, with stratified and unstratified drift-formations simultaneously; that icebergs had no part in the matter, and the supposed iceberg sea over New England no existence."

12. *On the Mixture of Cretaceous and Eocene Fossils*; by T. A. CONRAD, (communicated for this Journal).—We frequently hear of passage beds between the Chalk and Eocene, but the evidence is never produced which would show a gradual transition from one to the other. It has been said that in California such beds have been found; but Mr. Gabb in his extensive explorations did not observe them. The collection of fossil shells which he considered a newer Cretaceous formation, and designated as No. B is now in the collection of the Academy of Natural Sciences, and a careful revision of the species fails to enable us to detect one recognized form of the Cretaceous Period of California, or anywhere else. It is a peculiar group, however, unlike any other known. A glance at the large *Venericardia Hornii*, will strike any one accustomed to compare the Chalk and Eocene fossil shells as peculiarly indicating the Eocene. This statement of the distinct character of different formations, takes no account of those local mixtures of fossils which are easily traced to disturbances in the bed of the ocean.

13. *Diamonds in Australia.*—A letter from the Austrian Consul in Australia, to Mr. Hochstetter of Vienna, announces that the diamonds of Australia are remarkable for size as well as beauty. They vary in weight from half a carat to 150. One found on the property of the Consul, was of the first water, and weighed 30½ carats; and another, of 46 carats, was sold in London at 128,000 francs. The region especially abundant in diamonds is the frontier of the Orange River country, at Sikatlory.—*Les Mondes, Jan.* 13.

14. *The Æpyornis of Madagascar.*—MM. ALP. MILNE-EDWARDS and ALF. GRANDIDIER describe in Comptes Rendus, 11th Oct. 1869, certain curious anatomical peculiarities of the bones of the Æpyornis, and they observe "that it belongs to a group of shortwinged birds, but constitutes amongst them a type characterized by its massive forms, and by feet of a size difficult to conceive. It must be placed beside the dinornis and apteryx, although it is removed from them by important features of its organization, and by the pneumaticity of its thigh bones. The height of this bird was much less than J. Geoffroy St. Hilaire thought. Taking the length of its foot as a basis of calculation, the Madagascar bird scarcely exceeded two metres, which is the height of a large ostrich, while the *Dinornis giganteus* varied from two and a half to three metres. But if the Æpyornis is not, as was supposed, the

biggest of all these birds, it is the stoutest, the most massive, the most elephantine, if we may so express it."—*Student, Nov.* 1869.

15. *Preliminary Notice of the Lamellibranchiate Shells of the Upper Helderberg, Hamilton and Chemung Groups;* [*Preparatory Studies for the Palaeontology of New York*]; part 2; by JAMES HALL. 80 pp. 8vo. State Col. Nat. Hist. 1869.—This paper by Prof. Hall contains descriptions of several new genera and species, and revised references of other old species. The new genera are PALÆANEILO for *Nuculites constricta* Conrad, etc.; LIMOPTERA for *Lima macroptera* Conrad; MYTILARCA for *Megambonia ovata* Hall, etc.; PHOLADELLA for *Nuculites radiata* Conrad; CIMITARIA for *Cypricardites corrugata* Conrad, etc.; PHTHONIA for *Cypricardites sectifrons* Conrad; MODIOMOPHA for *Cypr. oblonga* Con. and *Modiola concentrica* Hall, etc.

III. ZOOLOGY.

1. *Molluscan Fauna of New Haven. A critical review of all the Marine, Fresh Water, and Land Mollusca of the region, with descriptions of many of the living animals and of two new species;* by GEO. H. PERKINS, Ph.D. From Proceedings of the Boston Society of Natural History, November and December, 1869.—The total number of species given in this catalogue is 162; of these 97 are Gasteropods (51 marine); 54 Lamellibranchs (40 marine). Of the 91 marine species 50 are said to occur north of Cape Cod; 13 in Labrador; 8 in Greenland; 8 in Europe; 51 extend to South Carolina and some of them farther; 37 occur in the Post Pliocene; 26 in the Pliocene; 19 in the Miocene. A list of 65 species recorded from Long I. Sound, but not yet found at New Haven, is given at the end. The two new species described and figured are *Nassa fretensis* (like *N. vibex*) and *Astarte lutea* (allied to *A. sulcata*). A new generic name, in errata *Tottenia* (by error *Tottenniana*) is proposed for *Venus gemma* Totten, and *Crassivenus* instead of *Mercenaria* for *Venus mercenaria* Linn., the name, *mercenaria*, being objectionable because properly a *specific* name and an adjective. *Mytilus hamatus* Say is referred to *Brachydontes*, and *Pleurotoma brunnea* is proposed for *P. plicata* Adams.

The synonomy is far from complete, and although completeness could hardly be expected in a catalogue of this kind, yet it seems desirable to give, if any, such references as are necessary to explain the nomenclature adopted and the principal synonyms in all cases. But besides want of completeness there are many positive errors that are scarcely excusable even in a local list. In looking it over casually the following errors were noticed, besides others of less importance.

Thus "*Melantho decisa* Binney," should have H. & A. Adams as authority, and "*Vivipara decisa* Gill" in the synonymy, should be *M. decisa* Gill, instead of omitting the reference entirely (as in errata), for Prof. Gill was the first to correctly limit the two genera, as found in this country.

The "*Cytherea Sayii* Conrad," p. 147, should be *Cytherea Sayana* Conrad, Jour. Phil. Academy, vol. vii, p. 124, 1834; the reference to Gould, "p. 34," should be p. 84; "*Callista convexa* Say," should be *Cytherea convexa* Say; and finally the correct reference for "*Callista convexa*" is Adams' Gen., ii, p. 425. This species is really a *Callista*, unless we adopt Römer's subgenus, *Caryatis*, to which it also belongs. But Conrad's grounds for rejecting Say's name, *convexa*, seem to be insufficient,—at least I am unable to find another species of *Callista* with the same name. "*Mercenaria violacea* Stimpson," should be *M. violacea* Schumacher, "*Modiola modiolus* Linn," should read *M. modiolus* Turton, (*Mytilus modiolus* Linn.), and *M. barbatus* is no doubt a distinct Mediterranean species. "*Scapharca transversa* Say," should be *S. transversa* H. & A. Adams, (*Arca transversa* Say).

The following names, quoted as having Stimpson (Check List), Tryon, Conrad, etc., as authorities, are found in H. & A. Adams' Genera of Recent Mollusca, and some of them, perhaps, in earlier works:—*Amycla Gouldiana*, *A. dissimilis*, *Tritia trivittata*, *Cerithiopsis Emersonii*, *Lunatia heros*, *L. triseriata*, *Turbonilla interrupta*, *T. nivea*, *Melantho decisa*, *Bittium Greenii*, *Tectura testudinalis*, *Martesia cuneiformis*, *Xylotrya palmulata*, *Siliqua costata*, *Angulus tenera*, *A. polita*, *Peronea tenta*, *Macoma fusca*, *Brachydontes plicatula*, *Scapharca transversa*. v.

IV. ASTRONOMY.

1. *Elements of Asteroid* (109); by E. H. F. Peters, of the Litchfield Observatory of Hamilton College. Communication dated Clinton, Oneida Co., N. Y., November 25, 1869.*—The following elements of asteroid (109) are computed from my observations of Oct. 9, 20 and 31.

Epoch 1869, Oct. 0·0 Berlin mean time.

Mean anomaly,	337°	1′	3″·35.	
Longitude of perihelion,	55	53	48·04.	Mean Equ. 1870·0
Longitude of node,	4	51	45·43.	Mean Equ. 1870·0
Inclination of ecliptic,	7	56	56·55.	Mean Equ. 1870·0
Angle of eccentricity,	17	25	14·13.	
Mean daily motion,			809″·580.	

Logarithm of major semi-axis, 0·4278314.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *On Force and Will;* by B. A. Gould.—(We copy the following from an able address of Dr. Gould, at a meeting of the American Association last August, at Salem, Mass., as retiring President of the Association.)—

Scientists are now of accord that "force can neither be created nor destroyed," and that "the quantity of force in nature is just as eternal and unalterable as the quantity of matter." Its various

* This announcement was issued on a loose slip in connection with the January number of this Journal.

forms are eminently convertible, yet utterly indestructible. And to avoid that fruitful source of disagreement among the ablest men, which has arisen from the ambiguous signification of the word, we must adopt the meaning which is finding general acceptance, and define force as "that which is expended in producing or resisting motion;" thus clearly discriminating between force and its cause.

In his retiring address before this Association, last year, our honored ex-president Dr. Barnard presented an argument, so vigorous and clear that I see no room for an adequate rejoiner, in opposition to the doctrine which would extend the principle of the conservation of force to the phenomena of consciousness,—"a philosophy which at the present day is boldly taught in public schools of science, and which numbers among its disciples many very able men." He says, for instance:—

"Organic changes are physical effects, and may be received without hesitation as the representative equivalents of physical forces expended. But sensation, will, emotion, passion, thought, are in no conceivable sense physical."—[*Proc. Amer. Assoc., Chicago*, p. 89.]

"The philosophy, which makes thought a form of force, makes thought a mode of motion; converts the thinking being into a mechanical automaton, whose sensations, emotions, intellections, are mere vibrations produced in its material substance by the play of physical forces, and whose conscious existence must forever cease when the exhausted organism shall at length fail to respond to these external impulses."—[*Ibid*, p. 91.]

"Thought cannot be physical force, because it admits of no measure. * * A thing unsusceptible of measure cannot be a quantity, and a thing that is not even a quantity cannot be a force."—[*Ibid.* pp. 93, 4.]

Before the cogent reasoning carried out by President Barnard, of which the general tenor is indicated by these quotations, the view that force affords a middle term between the moral and the material worlds can be sustained as little as the pure materialism against which the argument was directed. But if we ascend a grade higher, and consider that which guides and compels force, as force guides matter, I am disposed to believe that the problem may be nearer to a solution. Yet I offer my views with hesitation, not unmindful of the great thinkers who have considered these exalted topics, and shrinking from the rebuke of presumption.

There is an elegant experiment, in which the tension of a spring is made to produce heat by percussion, thus developing the current from a thermo-electric battery, which by successive modifications of its force exhibits heat, chemical action, magnetic attraction, and finally bends another spring; the same original force successively appearing in all these various manifestations until it is reëstablished in its primitive form. In such an experiment the imperfections of the apparatus would of course entail some loss at each successive step, and thus preclude the practical recovery of an available force equal to that expended in the original flexure of the spring. Yet the fact is beyond question that such loss is due solely to the inadequacy of our implements for collecting and transmitting the force at each stage of the experiment; for the law of conservation teaches that it is in every instance con-

verted into other form or forms without diminution. Could such an apparatus be constructed with theoretical perfection, it would represent an eternal circuit of force; and, like the frictionless pendulum in a vacuum, it would exhibit a perpetual motion, after the needful impulse had once been applied. The spring would oscillate forever, did no extraneous force oppose, whether the force producing its rebound were or were not transmitted through a chain of modifications.

In this inert apparatus no force whatever would have been embodied, yet qualities would have been implanted by design, which would compel an indestructible force, applied to it, to play the part of an unwilling Proteus. The influence seems unavoidable that force may be guided and controlled, compelled to exert itself in this or that shape, without the outlay of any other force for the purpose. If it be objected that it is an intrinsic law of force that it shall change its form in exerting itself, the case is in nowise altered by the expression of this truism. Our design has prescribed, and (extraneous force being absent) might indefinitely prescribe, the modes and directions in which that constant force should manifest itself.

Muscular force is directed, and in its vital action is usually controlled, by will. If we assume it to be coequal with the expenditure of tissue,* measurable alike by its transferred results and by the decomposition of this tissue, where and what is that power which lets loose or withholds this force, and whose action is attended by a conscious effort? It is the will,—a something which directs and controls force without expending it. Not only are thought and forms of consciousness not forces, if the reasoning already adduced be correct, but, although often moral incentives to the will, they are not even motive energies, in the sense in which I think we must concede the will to be such. It is true that the exercise of thought is followed by fatigue, yet it is not attended by a sense of effort, except in so far as it is directed by an exertion of the will. And although the former doubtless consumes tissue, have we any reason for believing that the exercise of will does the same, apart from that consumption which corresponds to the forces whose mode of action it prescribes?

Thus it would appear that the metamorphosis of force, though not "work done" in the mechanical sense, is the result of some definite mode of causation. What this causation is, and whether it is susceptible of measurement, are the next questions. In the same category with this agency, or energy, or influence, the vital principle would seem to belong,—directing forces while it neither expends nor consumes them. In the growth of organic beings, unstable combinations are formed, and organized structures are thence reared, in which, as Kant has so beautifully said, "all parts are mutually ends and means." If in such organic development force is consumed, disorganization without decomposition ought

* Even if it be also, to some extent, supplied by the disorganization of food not fully converted, the argument is not thereby affected.

to evolve it. Of the deposit of force in the unstable material of the tissues, I am not speaking, but of the vitality itself, which represents an energy requisite for the development and growth of organisms,—their dissolution being in turn attended by development of inferior forms of life, which suggest that this energy may have again been made available,—an energy too which is not "force," as this term has just now been defined.

No comparison can be drawn between vitality and those molecular forces which build the crystal. Crystaline forms arise when the molecular attractions enjoy the freest scope, and their construction must be attended by an evolution of force, which ought to be recognizable by physical tests, and which should also be measurable by an excess of their resistance to solution, over that of comparatively amorphous masses of the same material, in which equal weights present equal surfaces.

So, too, not only in that individuality which life confers and in the impossibility of insulating or transferring vitality, but also in its hereditary character and its apparent susceptibility of indefinite increase or diminution, the vital energy violates our fundamental conceptions of force, and demands a separate category, seeming to belong in the same with will. If will and life be forms of force, their total amount must be limited by the law of conservation. If, on the other hand, they are outside the realm of forces, we may more readily indulge the conviction to which experience would lead, that their freedom is unfettered by any restrictions within our knowledge,—each injoying an indefinite, though possibly a correlated scope in its own domain. The indestructibility of both matter and force implies a fixed coefficient of force for matter in equilibrium; but how great is the contrast offered in this respect by such energies as life and will!

Now if this reasoning be correct, we may have in this class of energies that middle term, so earnestly desired and so intensely needful, which unites the phenomena of matter with those of spirit, and forms the connecting link between science and religion; their harmonious conjunction affording the highest system of philosophy. It is this class of energies which, controlling the forces of matter, guides and governs their modifications and transformations. It is this, moreover, which, inseparable from mind, is exerted by all conscious organism. The mystic play of coequal, but to our senses, so dissimilar forces, and the equally recondite mutual action of the eye, the brain and the nerve, alike demand agencies transcending all our science, yet implicitly obeying physical laws. The highest manifestations of these agencies is in will; the highest agent is the Almighty. Thus the dictum of faith, that the universe exists only by virtue of the continued will of its Creator, represents a palpable scientific fact; and we may see that the pantheist, the materialist and the spiritualist (I will not be debarred from this noble word hy the associations of its misuse to-day) have been contemplating the same exalted truth from different aspects, with limited ranges of vision.

2. *On Auroral appearances and their connection with the phenomena of Terrestial Magnetism*; by BALFOUR STEWART, F.R.S. F.R.A.S.—Some years since, I ventured to suggest that auroral displays might be secondary currents due to small but rapid changes, caused by some unknown influence, in the magnetism of the earth. In developing this idea, the earth was compared to the core of a Ruhmkorff machine, and the moist upper strata of the earth, as well as the upper strata of the atmosphere, to secondary conductors, in which currents will take place whenever the magnetism of the earth changes from any cause. These views would appear to be confirmed by the very interesting records of earth-currents obtained by Mr. Airy at the Greenwich Observatory, in which it is found that during times of very great magnetic disturbance there are strong earth-currents alternating from positive to negative, the curves lying nearly equally on both sides of the zero.

A further development of this idea has lately occurred to me, in consequence of a remark of my friend Mr. Lockyer, that the zodiacal light may possibly be a terrestial phenomenon, and may therefore be somehow connected with the phenomena of terrestial magnetism. For not only will secondary currents be caused in a stationary conductor in presence of a magnetic core of variable power, but also in a conductor moving across the lines of force of a constant magnet. The question arises, have we on the earth such moving conductors? In answer to this, let us reflect what takes place at the equator. When once the anti-trades have reached the upper regions of the atmosphere, they will become conductors from their tenuity; and as they pass rapidly over the lines of the earth's magnetic force we may expect them to be the vehicles of an electric current, and possibly to be lit up as attenuated gases are when they conduct electricity. May not these form the zodiacal light?

Such moving currents will, of course, react on the magnetism of the earth. We may therefore suppose that somewhat sudden and violent changes are likely to take place in the earth's magnetism at those seasons at which the earth's great wind-currents change most rapidly. May not this account for the excess of disturbances at the equinoxes?

Besides the anti-trades there are also, no doubt, conviction-currents, caused by the daily progress of the sun, taking place in the upper regions of the earth's atmosphere. May not these also be vehicles of currents as they cross the lines of the earth's force, and account, to some extent at least, for the daily variations of terrestrial magnetism? and may not this be the reason of the likeness observed by Mr. Baxendell between the curves denoting the daily progress of the wind and those denoting the variations of the declination of the magnet? Such currents (in as far as they are electric conductors), taking place in the upper regions of the atmosphere, would not be felt by the earth-current wires at Greenwich, and I think Mr. Airy has noticed that this is the case. But the tidal wave represents a motion of a conductor on the earth's surface, with two periods in one lunar day. This motion cannot pro-

duce a very great secondary current; but may it not be sufficient to account for the lunar-diurnal magnetic variation, which is also very small?

Such a current taking place in a conductor electrically connected with the earth's upper surface ought to be felt by the Greenwich wires; and, if I am not mistaken, Dr. Airy has detected a current of this nature.

May we not also imagine that there are two varieties of aurora —one corresponding to stationary conductors under a very rapidly changing core, and the other to rapidly moving conductors under a constant core? And might not an aurora of the latter kind indicate the approach of a change of weather?

These remarks are thrown out in order to invite comment and criticism, and they will have served their purpose if they direct attention to the part that may be played by moving conductors in the phenomena of terestrial magnetism. It will be noticed that these remarks do not touch upon the mysterious connection believed to exist between magnetic disturbances and the frequency of solar spots.

P. S.—Since writing the above, Sir W. Thomson has called my attention to a paper by him in the Philosophical Magazine for December, 1851, in which it is suggested that moving conductors may play a part in the phenomena of terrestrial magnetism.—*Monthly Notice of the Royal Astronomical Society, Dec.* 10*th*, 1869.—*Phil. Mag.*, IV, xxxix, 159.

3. *The approach of violent storms announced by telegraph.*—In December, 1869, a memorial was presented to the House of Representatives, from Prof. J. A. Lapham, of Milwaukee, Wisc., calling the attention of Congress to the fearful loss of life and property occurring annually on our Great Lakes, and suggesting the possibility of doing something to prevent at least a portion of this loss in future. A bill was at once introduced by Hon. Halbert E. Paine, of Wisconsin, providing that the Secretary of War be authorized and required to provide for taking the necessary meteorological observations, at the military stations in the interior of the continent, and for giving notice on the northern lakes and Atlantic coast, by means of the electric telegraph, of the approach and force of storms. Letters were subsequently presented to the House of Representatives, from the Surgeon General of the U. S. Army, from Prof. Joseph Henry of the Smithsonian Institution, from Prof. Elias Loomis of Yale College, and from the chief Signal Officer of the U. S. Army, approving of the proposal of storm warnings, and suggesting some of the advantages which might be expected to result from them. The bill was passed in the House of Representatives, Feb. 2, and in the Senate Feb. 4, 1870. The following is a copy of the bill as adopted:—

"Be it resolved, etc., That the Secretary of War be and he hereby is authorized and required to provide for taking meteorological observations at the military stations in the interior of the continent, and at other points in the States and Territories of the United States, and for giving notice on the northern lakes and on

the sea coast, by magnetic telegraph and marine signals, of the approach and force of storms."

If the system authorized by this act should be prosecuted earnestly and faithfully by the War Department, we anticipate that it will result not only in an important addition to our knowledge of the laws of storms, but will materially diminish the number and severity of marine disasters. Systems of this kind are already in operation in England, France, Holland, Italy, and other countries, and are producing important results. Our Atlantic seaboard is more favorably situated for receiving intelligence of approaching storms, than the western coast of Europe, since a majority of our violent storms have their origin on the land, and moving eastward may be telegraphed in advance to the principal commercial cities of the Atlantic coast.

4. *The Sars Fund.**—We are glad to find that the appeal made in our pages by Mr. Gwyn Jeffreys, on behalf of the family of the late Professor Sars of Christiania, is being warmly seconded in Paris by M. Alglave, the editor of the *Revue des Cours Scientifiques.* In the last number of the *Revue* Mr. Gwyn Jeffreys' article is reprinted *in extenso*, and an announcement made that subscriptions to the Sars Fund will be received at the office of that journal. But M. Alglave has not waited for the publication of his notice before beginning his good work; he has already collected the sum of 2,026 francs (81*l.*), and publishes with the notice a first subscription-list containing the names of many of the most eminent naturalists in France. We have now the pleasure of giving in our advertising columns a list of the contributions already promised to Mr. Gwyn Jeffreys. Sars belonged to the best type of scientific men, the genuine lover of science, contented to work in obscurity without thought of honors or reward. His family have a special claim to help, inasmuch as the distress in which they are left is not due to neglect or extravagance on the part of the lamented Professor, but is solely attributable to his having devoted himself to studies, which, notwithstanding the most self-denying labors, did not enable him to make any provision for the future. Those of our readers who have visited Norway, who know the genuine unworldly ways of the Norwegians, and who have enjoyed the enthusiastic welcome so readily given to the English, have now a graceful opportunity of reciprocating the kindly feeling shown them by the countrymen of Sars.—*Nature, Feb.* 3.

5. *The Family of the late Prof. Michael Sars.*—In a notice of Prof. Sars, the editors state in the American Naturalist, Salem, Mass., of March, 1869, that in view of the fact that American Zoölogists are deeply indebted to Prof. Sars for the light he has thrown upon many of the lower animals, in the unrivalled investigation embodied in his publications, we feel it a duty to solicit aid for his family. Any sum, however small, which may be sent them will be welcomed, acknowledged and forwarded to his family through the Norwegian Minister.

* The death of this eminent zoologist of Norway, Mr. Sars, is mentioned in our January number, on page 144.

6. *Lighting Power for Buoys. Premium for the year* 1871 *offered by the Netherland Society for the Promotion of Industry.*—One of the greatest impediments to navigation is darkness in buoyed waters. If it were possible to develop a lighting power in the buoys, this difficulty would be greatly diminished, to the advantage of navigation.

The Society offers, therefore, her gold medal (representing a value of hundred fifty florins, Neth. Cy.) and an award of three hundred florins for the most practical means of investing buoys with a lighting power, for service at night.

Conditions.—1. The answers must bear a distinctive mark, epigram or motto, and be accompanied by a sealed envelope, containing the competitor's name, and bearing outside the same mark, epigram or motto as above.

2. The competitors are requested to communicate an intermediate address, in case of eventual correspondence.

3. The answers and any other accompanying writing must not be in the competitor's own hand.

4. The successful answer becomes the property of the Society, which reserves to itself the right of publication.

5. The Society takes no responsibility for eventual damage to models or instruments, illustrative of the answers, and reserves to itself the right of not returning them to the competitors.

6. Answers are requested post paid before the 30th of September, 1871, to the address of the General Secretary and Treasurer of the Society, F. W. Van Eeden, Haarlem, the Netherlands.

7. *Academy of Sciences, Paris.*—Mr. A. DesCloizeaux, the distinguished Crystallographer and Mineralogist, whose optical researches in connection with crystals have done so much to advance the science of mineralogy, has been elected a member of the Academy in place of the late Mr. d'Archiac; and Professor Mayer, the eminent physicist, in place of the late Professor Matteucci.

OBITUARY.

Rev. George Jones, U. S. N.—On the 22d of January, 1870, at the Naval Asylum, in Philadelphia, died Rev. George Jones, long connected with the United States Navy as a Professor and a Chaplain; but better known in science for his important contributions to our knowledge of the zodiacal light. His labors in this department fill the third volume of the U. S. Japan Expedition, embracing observations from April 2d, 1853, to April 23d, 1855, made chiefly on board the U. S. steam frigate Mississippi, and are included on 340 charts, followed by Cassini's observations (10 in number) in 1685 and 1687. In his Introduction to this volume, Mr. Jones expresses his intention to spend a year at Quito, Ecuador, with a view to compare and extend his zodiacal light observations from that equatorial and lofty position. This purpose he executed in the year 1856, adding greatly to the fullness of his researches upon this wonderful phenomenon. A summary, by himself, of his observations in Ecuador was published, with three plates, in vol. xxiv of this Journal, 1857, p. 374; but the great mass of data then col-

lected remain still unpublished. Mr Jones was a patient and most conscientious observer, and his contributions in this department of astronomy must ever form an important feature in any discussion of the phenomenon, notwithstanding Prof. Piazzi Smyth's most extraordinary and flippant assertion that Mr. Jones had never seen the zodiacal light at all!

Mr. Jones was the author of Sketches of Naval Life, 2 vols., New Haven, 1829, and Excursions to Cairo, Jerusalem, &c., one volume, New York, 1836, besides other works of a religious character. It was largely owing to the asssiduity and patient tact of Mr. Jones that the U. S. Naval Academy was created against the instructive prejudices of most of the older naval commanders, a labor for which he never sought credit or fame, but not the less worthy of being remembered and recorded to his lasting honor. Mr. Jones graduated at Yale College in 1823, and was a tutor there from 1828 to 1830.

VI. MISCELLANEOUS BIBLIOGRAPHY.

1. *Transactions of the Chicago Academy of Science*, Vol. I, Part II, 1869. Large 8vo, with steel engraving and fourteen plates.—The first volume of Transactions of the Chicago Academy, now completed, does great honor to the society and to the enlightened liberality of those gentlemen who have furnished the means of illustrating it with so many beautiful plates. The first article is a biographical sketch of Dr. Robert Kennicott, the late Director of the Academy, with portrait and interesting extracts from the diaries, written during his well-known arctic explorations. The article on the Antiquity of Man in North America, by Dr. J. W. Foster, is of special interest at this time, and contains a summary of all the evidences hitherto obtained upon the subject. It is illustrated by six plates. The "List of the birds of Alaska, with biographical notes," by Wm. H. Dall and H. M. Bannister, and Prof. Spencer F. Baird's descriptive list of the "Additions to the Bird-Fauna of North America made by the Scientific Corps of the Russo-American Telegraph Expedition," illustrated by excellent colored plates of all the species, are very valuable contributions to American Ornithology. In the former 212 species of Alaska birds are enumerated, with valuable notes on their habits and distribution. Mr. S. H. Scudder enumerates 46 species of butterflies collected by J. A. Allen in Iowa, several of which are described as new. V.

2. *Guide to the Study of Insects;* by A. S. Packard, Jr., M. D. 8vo, 702 pages, with eleven plates and 650 wood-cuts. Salem, Mass., 1869. Naturalist's Book Agency.—This excellent work, published in ten numbers, is now completed. It is really an admirable manual of entomology by an author thoroughly versed in the science, and who is at the same time an original investigator. On this account it has a much higher character than a mere compilation, which is too seldom the case with scientific manuals and text books. The work is well illustrated, and followed by a

glossary and full index. The structure and classification of insects are fully discussed, as far as the families and the prominent genera and species in each family are described. It includes also full directions for collecting and preserving insects, and various other useful information on transformations, habits, distribution, geological history, etc., as well as descriptions of new species and genera in some of the orders. It embraces the *Arachnida* and *Myriapoda* as well as the Hexapod insects, which is quite unusual in treatises on entomology. V.

3. *Theory of Existence:* Part I. Devoted to the enunciation of the laws which determine the motions that result from the collision of ponderable bodies; by ELIAS DEXTER. 156 pp. 8vo, with 5 plates. 1869. New York. (Edward Dexter, 564 Broadway). —The laws enunciated in this singular book, beginning with the first paragraph defining velocity, are, with few exceptions, entirely at variance with the received principles of mechanics, so that in the concluding sections, which are devoted to the refutation of Newton's Laws of Motion, the author finds it easy to show by reference to the earlier part of his own book, that the views of Newton are quite erroneous. The age is prolific in such waste efforts by the "advance men" of the times.

4. *A Practical Treatise on Metallurgy adapted from the last London edition of Professor Kerl's Metallurgy.* Vol. iii; *Steel, Fuel, Supplement;* illustrated with 145 wood engravings; by WILLIAM CROOKES, F.R.S., and ERNST RÖHRIG, PH.D., M.E. 820 pp. 8vo. New York, 1870. (John Wiley & Son.)—This volume is a most valuable addition to our previous literature upon the important subjects of which it treats, and it is not too much to say that the metallurgical student will seek in vain, elsewhere, for such a comprehensive summary of recent progress in this department of knowledge. The arrangement of the materials is excellent and the subjects are discussed with all desirable fulness; thus the Bessemer steel process covers 80 pages; while proper notice is taken of all other methods, even to the Ellershausen process, Bessemer's new system of high pressure, hot blast furnaces, and Siemen's process of producing steel direct from the ores. The table of contents covers 21 pages, and exhibits clearly the great range of interesting topics which fills the volume. Full references to original memoirs in all languages bearing on steel and fuel add value to the work. This is altogether the most important contribution of the three volumes, of which it is the last as well as best.

5. *Lithology of the Seas of the Old World;* by M. DELESSE.—Of this work by M. Delesse we have seen only the chart. In the work the author, as is stated in a resumé received from him, takes up the lakes and seas of the old world in succession, describes their several features, or peculiarities, the character of the shores and bottom, and the relative amount of life distributed over the several parts. The subject is one of great interest and if thoroughly carried out, would make a very important contribution to the sciences of geology and physical geography. The map is an exceedingly beautiful example of engraving and coloring.

6. "*Nature.*"—This scientific weekly, published by MacMillan & Co., London,* the first number of which was noticed in our last volume (p. 451) sustains well the promises made in its prospectus. It is popular in the character of many of its articles, and well furnished with the scientific news of the day, besides reviews of new works. It is not in any proper sense a special organ of Darwinism, which the first number seemed to suggest. Illustrations are often given when the subjects require it. The number for December contains a map of a part of Africa, presenting a view of the recent discoveries and Livingstone's route, which would be convenient to readers of Livingstone's letter in the last number of this Journal, and that for Jan. 20th has a map of the polar regions, and the routes of the recent exploring parties in that direction.

7. *Paris Universal Exposition*, 1867; *Reports of the United States Commissioners.*—We have already made mention of some of the more important of these Reports, and have offered the titles of all which have appeared up to this time, and copies of which have reached us by the courtesy of the editor, Professor Wm. P. Blake, who has carried these documents through the press in a manner creditable to the occasion.

Machinery and Processes of the Industrial Arts, and Apparatus of the Exact Sciences; by Frederick A. P. Barnard, LL.D. pp. 669. Plates.

Examination of the Telegraphic Apparatus, and the Processes in Telegraphy; by Samuel F. B. Morse, LL.D. pp. 166. Plates.

The Production of Iron and Steel in its Economic and Social Relations; by Abram S. Hewitt. pp. 183. Plates.

Report upon the Precious Metals: being statistical notices of the principal gold and silver-producing regions of the world, represented at the Paris Universal Exposition; by William P. Blake. pp. 669.

The Progress and Condition of Industrial Chemistry; by J. Lawrence Smith. pp. 146. Plates.

General Survey of the Exhibition, with a Report on the Character and Condition of the United States Section. pp. 324.

The Manufacture of Beet Sugar and Alcohol, and the Cultivation of Sugar Beet; by Henry F. Q. D'Aligny. pp. 90. Plates.

Report on Corals; by Samuel B. Ruggles and G. S. Hazard. pp. 26.

Report upon Cotton; by E. R. Mudge, with a Supplemental Report by B. F. Nourse. pp. 115.

Report upon Buildings, Building Materials and Methods of Building; by James H. Bowen. pp. 96.

Report upon Wool and Manufacturers of Wool; by E. R. Mudge, assisted by John L. Hayes. pp. 143.

Preparation of Food. Pressed or Agglomerated food. Culture and Products of the Vine. Photographs and Photographic Apparatus. Outline of the History of the Atlantic Cable. School Houses and the Means of Promoting Popular Education.

* The subscription price for "Nature" is fourpence; or for America, as announced by the house of Macmillan & Co., 63 Bleeker st., New York, 12 cents a number, and $5.00 a year.

Report on Silk and Silk Manufacturers; by ELIOT C. COWDIN. pp. 51.

Report on Instruments and Apparatus of Medical Surgery and Hygiene; by THOMAS W. EVANS, M.D. pp. 70.

Report on the Fine Arts, and the Fine Arts applied to the Useful Arts; by FRANK LESLIE, S. F. B. MORSE and THOMAS W. EVANS. pp. 43. Plates.

Report on Béton-Coignet: its fabrication and uses. Report on asphalt and bitumen, and their application to streets, roads, buildings, &c.; by ARTHUR BECKWITH. pp. 21, and 31 plates.

Report upon Steam Engineering, as illustrated by the Paris Universal Exposition, 1867; by WILLIAM S. AUCHINCLOSS. pp. 72.

Report on the Munitions of War; by CHAS. B. NORTON and W. J. VALENTINE. pp. 213.

In addition to the foregoing reports, there are yet to come others on the following subjects: *Mining; Clothing; Engineering Works; Education; The history of the Organization and Progress of the Exhibition;* including *titles, list of reports, authors, tables of weights and measures, etc.* The whole series will be bound in six volumes of some 600–700 pages each.

PROCEEDINGS AMERICAN PHILOSOPHICAL SOC., Vol. XI.—p. 119, Prodromus of a study of the Fresh Water Algæ of Eastern North America; *H. C. Wood, Jr.*—p. 147, Seventh Contribution to the Herpetology of Tropical America; *E. D. Cope.*—p. 171, Synopsis of the Extinct Mammalia of the Cave Formations in the United States, with observations on some Myriapoda found in and near the same; *E. D. Cope.*—p. 195, Some Suggestions on the maintaining forces of Cosmical motion; *W. H. Lowrie.*—p. 202, Tidal Rain-fall; *P. E. Chase.*—p. 204, Abstract of Results of Measurements and Examinations of the Photographs of the Total Eclipse of Aug. 7, 1869; *A. Mayer.*—p. 209, Profile of Recent Flood in the Schuylkill; *J. C. Cresson.*—p. 213, Indian Relics from New Jersey; *G. B. Wood.*—p. 215, Comets and Meteors; *D. Kirkwood.*—p. 220, Search for a Normal Cause of the Recession of Cosmical Nodes; *W. H. Lowrie.*—226, Medical Activity of the Hemp Plant as grown in North America; *H. C. Wood, Jr.*—p. 233, Silver Coins; *W. E. DuBois.*—p. 235, Coal Borings in the Wilkesbarre Basin; *P. W. Sheafer.*—p. 237, Supposed Laurentian Fossil; *R. J. Roscoe.*—p. 237, Experiment on the Revival of Peach Trees; *G. B. Wood.*—p. 240, Second Addition to the History of the Fishes of the Cretaceous of the United States; *E. D. Cope.*

PROCEEDINGS BOSTON SOC. NAT. HIST., Vol. XIII.—p. 139, Molluscan Fauna of New Haven, part II, Acephala and Bryozoa; *G. H. Perkins.*—p. 167, Occurrence of the Remains of *Turandus rangifer* Gray, at Big Bone Lick, Kentucky; *N. S. Shaler.*—p. 169, American Lepidoptera, II, Phalænidæ; *C. S. Minot.*—p. 172. Native Carbonate of Magnesia from California; *C. T. Jackson.*—p. 172, Remarks on the Relations of the Rocks in the vicinity of Boston; *N. S. Shaler.*—p. 178, Notes on the Mammals of Iowa; *J. A. Allen.*

ANNALS LYC. NAT. HIST. OF NEW YORK. Vol. IX, No. 8.—p. 237, Catalogue of Birds from Puna Island, Gulf of Guayaquil, in the Museum of the Smithsonian Institution, collected by J. F. Reeve; *G. N. Lawrence.* (Continued.)—p. 238, Additional Notes on the Geographical Distribution of Land Shells in the West Indies; *T. Bland.*—p. 242, Note on Lovén's Article on "Leskia mirabilis, Gray;" *A. Agassiz.*—p. 246, Observations on a Collection of Chalchihuitls from Central America; *E. G. Squier.*—p. 265, Characters of some New South American Birds, with Notes on other rare or little known Species; *G. N. Lawrence.*—p. 276, On the names applied to Pisidium, a genus of Corbiculadæ; *T. Prime.*—p. 280, List of the Species of Mollusca found in the vicinity of North Conway, New Hampshire; *T. Prime.*